CLERK'S COPY.

Vol. I

TRANSCRIPT OF RECORD

(Pages 1 to 272)

Supreme Court of the United States

OCTOBER TERM, 1945

No. 290

HALLIBURTON OIL WELL CEMENTING COMPANY, PETITIONER,

vs.

CRANFORD P. WALKER AND CRANFORD P. WALKER, D. A. WALKER, ET AL., DOING BUSINESS AS DEPTHOGRAPH COMPANY, COPARTNERSHIP

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT

PETITION FOR CERTIORARI FILED AUGUST 8, 1945.

CERTIORARI GRANTED OCTOBER 15, 1945.

Office - Supreme Court, U. S.
FILED
AUG 2 1945
CHARLES ELMORE CROPLEY
CLERK

TRANSCRIPT OF RECORD
IN SIX VOLUMES

IN THE

Supreme Court of the United States

October Term, 1945

No. 290

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Petitioner,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Respondents.

VOLUME I

Pages 1 to 272

UPON PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT

Rotary Coldprint, 661 Howard Street, San Francisco

No. 10513

United States
Circuit Court of Appeals
For the Ninth Circuit.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Appellant,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Appellees.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Appellants,

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Appellee.

Transcript of Record

In Five Volumes
VOLUME I
Pages 1 to 272

Upon Appeals from the District Court of the United States for the Southern District of California, Central Division

Rotary Colorprint, 590 Folsom St., San Francisco

INDEX

[Clerk's Note: When deemed likely to be of an important nature, errors or doubtful matters appearing in the original certified record are printed literally in italic; and, likewise, cancelled matter appearing in the original certified record is printed and cancelled herein accordingly. When possible, an omission from the text is indicated by printing in italic the two words between which the omission seems to occur.]

Page

Answer of Defendant, Amended 9

Appeal:

Bond on (Plaintiffs') 45

Certificate of Clerk to Transcript of Record on 562

Cost Bond on (Defendant's) 37

Designation of Contents of Record on:

Defendant's Additional (DC) 558

Defendant's (DC) 549

Halliburton Oil Well Cementing Co. (CCA) 571

Plaintiffs' (CCA) 580

Plaintiffs' (DC) 555

Notice of (Defendant's) 36

Notice of (Plaintiffs') 44

Statement of Points on:

Defendant-Appellant's (CCA) 565

Defendant-Appellant's (DC) 39

Plaintiffs'-Appellants' (CCA) 583

Plaintiffs' and Cross-Appellants' (DC) 48

Index **Page**

Appeal—(Continued):

Stipulation and Order Extending Time for Defendant to File Designation of Additional Portions of Record on 557

Stipulation and Order Extending Time to Docket 561

Stipulation and Order for Transmission of Exhibits on 547

Stipulation and Order re Insertion of Excerpts in the Record on..... 548

Stipulation Regarding Printing of Exhibits on 578

Bill of Complaint 2

Bill of Particulars 6

Bond on Appeal, Plaintiffs' 45

Certificate of Clerk to Transcript of Record on Appeal 562

Complaint, Bill of 2

Conclusions of Law 31

Cost Bond on Appeal, Defendant's 37

Decree 33

Designation of Contents of Record on Appeal:

Defendant's Additional (DC) 558

Defendant's (DC) 549

Halliburton Oil Well Cementing Co. (CCA) 571

Index **Page**

Designation of Contents of Record on Appeal—(Continued):

Plaintiffs' (CCA) 580

Plaintiffs' (DC) 555

Findings of Fact and Conclusions of Law..... 27

Names and Addresses of Attorneys..... 1

Narrative Statement of Testimony and Proceedings in District Court 51

Notice of Appeal:

Defendant's 36

Plaintiffs' 44

Order Extending Time for Defendant to Docket Appeal 560

Order Extending Time for Defendant to File Designation of Additional Portions of Record on Appeal 558

Order Extending Time for Plaintiffs to Docket Appeal 561

Order Extending Time to Docket Appeals, Stipulation and 561

Order for Transmission of Exhibits to Circuit Court of Appeals, Stipulation and 547

Order re Insertion of Excerpts in the Record on Appeal, Stipulation and 548

Particulars, Bill of 6

Index Page

Statement of Points to be Relied Upon on Appeal:

Defendant-Appellant's (CCA) 565

Defendant-Appellant's (DC) 39

Plaintiffs'-Appellants' (CCA) 583

Plaintiffs' and Cross-Appellants' (DC) ... 48

Stipulation and Order Extending Time for Defendant to File Designation of Additional Portions of Record on Appeal 557

Stipulation and Order Extending Time to Docket Appeals 561

Stipulation and Order for Transmission of Exhibits to Circuit Court of Appeals 547

Stipulation and Order re Insertion of Excerpts in the Record on Appeal 548

Stipulation Regarding Printing of Exhibits (CCA) 578

Testimony and Proceedings (Narrative Statement) 51

Exhibits for Defendant:

A—Certified Copy of File Wrapper and Contents of Abandoned Application of Cranford P. Walker, No. 270,865, filed April 29, 1939 783-832

Admitted in Evidence 61

Index Page

Exhibits for Defendant—(Continued):

B—Certified Copy of File Wrapper and Contents of Application which Resulted in Patent No. 2,209,944, in suit, filed Sept. 25, 1939 832-882

Admitted in Evidence 61

C—Graph made by Echo-Meter at the Trial in Demonstrating Apparatus to the Court in Recording Echoes in Rubber Hose 883

Admitted in Evidence 278

D—Graphs made by Echo-Meter in Demonstrating Apparatus to Plaintiff before Trial at Union Oil Co. Well Callender #79 884

Admitted in Evidence 280

F—Graph made at Duncan, Okla., by Apparatus constructed by Defendant in accordance with Patent to Lehr and Wyatt No. 2,047,974 using a hot wire microphone 885

Admitted in Evidence 292

F-1—Same as Exhibit F with marks placed thereon by Dr. Mackeown at the Trial 886

Admitted in Evidence 429

Index **Page**

Exhibits for Defendant—(Continued):

G—Graph made at Duncan, Okla. by Apparatus constructed by Defendant in accordance with Lehr and Wyatt Patent 2,047,974 using a carbon microphone 887

Admitted in Evidence 292

H—Photograph showing Lehr and Wyatt Apparatus built by Defendant attached to the well at Duncan, Okla. on which tests were made 888

Admitted in Evidence 325

I—Photograph showing Wyatt and Lehr Apparatus using Carbon Microphone attached to the Well at Duncan, Okla. 889

Admitted in Evidence 325

J—Photograph of Defendant's Commercial Apparatus, the Echo-Meter 890

Admitted in Evidence 325

K-1—Prior Publication—Wilde and Moore, 1931 891-897

Admitted in Evidence 242

K-2—Prior Publication—Gill, 1932....898-903

Admitted in Evidence 242

Index Page

Exhibits for Defendant—(Continued):

K-3—Prior Publication—Hawthorn, 1933 904-925

Admitted in Evidence 242

K-4—Prior Publication—Tucker, 1923 926-942

Admitted in Evidence 242

K-5—Prior Publication—Ihrig, 1935..... 943

Admitted in Evidence 242

K-8—Page 194, Prior Publication—Millikan, 1930 945

Admitted in Evidence 242

K-9—Prior Publication—Vietti, 1931 . 947-952

Admitted in Evidence 242

L—File Wrapper and Contents of Walker Application No. 164,534, filed Sept. 18, 1937, Disclosing Electrical Recording System 953-1063

Admitted in Evidence 514

O-2—Prior Patent — Batcheller 602,422, Apr. 19, 1898 1065-1072

Admitted in Evidence 243

O-4—Prior Patent—Fessenden 1,240,328, Sept. 18, 1917 1073-1076

Admitted in Evidence 243

Index Page

Exhibits for Defendant—(Continued):

O-5—Prior Patent—Tucker 1,351,356, Aug. 21, 1920 1077-1088

Admitted in Evidence 243

O-7—Prior Patent — Williams 1,671,262, May 29, 1928 1089-1094

Admitted in Evidence 243

O-9—Prior Patent—Taylor 1,847,636, Mar. 1, 1932 1095-1100

Admitted in Evidence 243

O-13—Prior Patent—Scott 2,173,426, Aug. 30, 1937 1107-1130

Admitted in Evidence 243

O-14—Prior Patent—Halliburton 2,201,-311, May 21, 1940 1133-1140

Admitted in Evidence 243

Q—File Wrapper and Contents of Walker Application Serial No. 171,170, filed Oct. 26, 1937, on Method of Determining Fluid Density, etc. 1141-1315

Admitted in Evidence 435

R—File Wrapper and Contents of Walker Patent 2,161,733, granted June 6, 1939 on Method of Determining Fluid Density, etc. 1315-1360

Admitted in Evidence 435

Index **Page**

Exhibits for Defendant—(Continued):

S—File Wrapper and Contents of Walker Reissue Patent 21,383 (in suit) granted Mar. 5, 1940 1360-1414

Admitted in Evidence 436

T—File Wrapper and Contents of Walker Patent 2,156,519 (in suit) granted May 2, 1939 for Means for Measuring the Location of Obstructions in Wells 1415-1543

Admitted in Evidence 513

U—File Wrapper and Contents of Wyatt and Lehr Patent 2,047,974, granted July 21, 1936 for Method and Apparatus for Measuring Well Depths 1544-1591

Admitted in Evidence 513

Exhibits for Plaintiffs:

1—Walker Patent 2,156,519 in suit....587-598

Admitted in Evidence 52

2—Walker Patent Reissue 21,383 in suit 599-607

Admitted in Evidence 52

3—Walker Patent 2,209,944 in suit...609-617

Admitted in Evidence 52

Index Page

Exhibits for Plaintiffs—(Continued):

6—Echo-Meter Folder Describing Defendant's Apparatus 619-629

Admitted in Evidence 53

7—Echo-Meter Advertisement 635-636

Admitted in Evidence 53

8—A, B, C, D, Echo-Meter Field Data, Surf Associates Well—State #1..637-642

Admitted in Evidence 53

9—Echo-Meter Field Data on Surf Associates Well—State #1.....643-645

Admitted in Evidence 54

10, 11, 12—Plaintiffs' Interrogatories and Defendant's Answers Thereto (combined and Abridged) 646-712

Admitted in Evidence 54

10-A—Drawing — Plaintiffs' Illustration of Defendant's Apparatus 713

Admitted in Evidence 54

10-B—Graphs made by Defendant's Echo-Meter on Cities Service Well—Ray B-2 714

Admitted in Evidence 54

Index Page

Exhibits for Plaintiffs—(Continued):

10-C—Graphs made by Defendant's Echo-Meter on Phillips Petroleum Co. Well, Kraft #3 715

Admitted in Evidence 54

11-A—Graph made by Defendant's Echo-Meter on Union Oil Co. Well—Stinson #1 716

Admitted in Evidence 55

11-B—Graph made by Defendant's Echo-Meter on Pace Pet. Corp. Well—McMasters B-1 717

Admitted in Evidence 55

11-C—Echo-Meter Field Manuel ..719-753

Admitted in Evidence 55

12-A—Drawing of Echo-Meter Casinghead Unit 754

Admitted in Evidence 55

12-B—Photograph of Echo-Meter Casinghead Unit 755

Admitted in Evidence 55

12-C—Photograph of Parts of Echo-Meter Casinghead Unit 756

Admitted in Evidence 55

12-D—Photograph of Echo-Meter Electrical Recording Instrument 757

Admitted in Evidence 55

Index **Page**

Exhibits for Plaintiffs—(Continued):

12-E—Calibration Curve used to Calibrate Filter in Defendant's Echo-Meter Recorder 758

Admitted in Evidence 55

13—Stipulation as to Certain Facts....759-767

Admitted in Evidence 56

14—Drawing—Plaintiffs' Illustration of Defendant's Apparatus (Drawing of Ex. 10-A slightly modified)..... 768

Admitted in Evidence 325

18—Prior Art Patent to Lehr and Wyatt, 2,047,974 .....769, 1101

Admitted in Evidence 156

19—Graph made by Walker at Shell Oil Co. Well Cosbloom No. 1, Nov. 19, 1935, in attempt to operate Apparatus like that of Lehr and Wyatt Patent... 771

Admitted in Evidence 159

20—Graph made by Walker on Nov. 20, 1935 in Attempt to Operate Apparatus like that of Lehr and Wyatt Patent.. 772

Admitted in Evidence 759

Index Page

Exhibits for Plaintiffs—(Continued):

21—Graph made by Walker at Shell Oil Co. Well—Cosbloom #1, Dec. 12, 1935, with Depthograph Apparatus having no Acoustically Tuned Resonator Therein 773

Admitted in Evidence 170

22—Copy of Drawing made by Walker on Blackboard in Court at Trial to Illustrate Typical Conditions in Well and Pressure and Rarefaction Waves..... 774

Admitted in Evidence 181

23—Commercial Graph made by Walker at Well—Alamitos No. 39, Mar. 6, 1936, with Depthograph having no Acoustically Tuned Resonator Therein and with no Tubing in the Well..... 775

Admitted in Evidence 185

24—Graph made by Walker at Well—Nesa #1, Mar. 7, 1936, with Depthograph Apparatus having no Acoustically Tuned Resonator Therein and with no Tubing in the Well 776

Admitted in Evidence 187

Index **Page**

Exhibits for Plaintiffs—(Continued):

25—Charts made with Depthograph on Well #109 showing Effects of use of Acoustically Tuned Resonator When Tuned to Tubing Collars and When Tuned to Casing Joints..... 777

Admitted in Evidence 198

26—Chart made with Depthograph on Well —El Segundo, Apr. 24, 1937, showing Effects of use of Acoustically Tuned Resonator 778

Admitted in Evidence 223

27—Photograph of Depthograph Apparatus 779

Admitted in Evidence 224

28—Photograph of Depthograph Apparatus and Man Operating Same..... 780

Admitted in Evidence 224

29—Copy of Drawing made by Walker on Blackboard in Court at Trial to Illustrate Effects of Tubing Collars, Casing Joints and Perforations in Pipe on Charts made with Directional and Non-Directional Microphones 781

Admitted in Evidence 240

Index Page

Witnesses for Defendant:

Cornes, Randolph W.

—direct 273

—cross 298

—redirect 324

Lehr, Paul E.

—direct 262

—cross 272

Mackeown, Samuel S.

—direct 325

—cross 418

—redirect 485

Pyle, Howard C.

—direct 487

—cross 501

Rubel, Albert C.

—direct 505

—cross 511

Walker, Cranford P.

—direct 514

Wyatt, Harold T.

—direct 244

Index Page

Witnesses for Plaintiffs:

French, Richard W. Jr.

—direct 122

—cross 142

—redirect 146

—recross 151

Gilbert, Emmet Walton

—direct 106

—cross 120

—redirect 122

Morris, Malcolm Wells

—direct 61

—cross 90

—redirect 102

—recross 103

Walker, Cranford P.

—direct 153

—cross 227

—recalled, direct 518

—cross 527

Proceedings in U. S. C. C. A., Ninth Circuit 1593
Order of submission 1593
Order directing filing of opinion and decree 1593
Opinion, Healy, J. 1594
Decree 1612
Order directing filing of opinions on petition for rehearing and denying petition 1613
Opinion, per curiam, upon petition for rehearing 1614
Concurring opinion, Denman, J., upon petition for rehearing 1614
Clerk's certificate 1617
Order allowing certiorari 1618

NAMES AND ADDRESSES OF ATTORNEYS:

For Appellant and Cross-Appellee:

FRANK L. A. GRAHAM
WILLIAM R. GRAHAM

811 W. 7th Street
Los Angeles, Calif.

EARL BABCOCK

Duncan, Oklahoma

For Appellee and Cross-Appellant:

HAROLD W. MATTINGLY
ROBERT W. FULWIDER,

621 S. Hope Street
Los Angeles, Calif.

[1*]

*Page numbering appearing at foot of page of original certified

In the United States District Court, Southern District of California, Central Division

No. 1655-H

Civil

CRANFORD P. WALKER; and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as DEPTHOGRAPH COMPANY, a co-partnership,

Plaintiffs,

v.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Defendant,

For Infringement of United States Letters Patent Nos. 2,156,519, 2,209,944 and Re. 21,383

[2]

BILL OF COMPLAINT

Now come Cranford P. Walker, and Cranford P. Walker, D. A. Walker, Robert P. Miller and Milo C. Ketchum, doing business as Depthograph Company, a co-partnership, plaintiff in the above entitled action, and complain of Halliburton Oil Well Cementing Company, a corporation, defendant herein, and for cause of action allege:

I.

That Cranford P. Walker at all of the times hereinafter mentioned was and is a citizen, inhabitant and resident of San Marino, County of

Los Angeles, State of California, within the Southern District of California, Central Division.

II.

That Cranford P. Walker, D. A. Walker, Robert P. Miller and Milo C. Ketchum, doing business as Depthograph Company, all reside within the County of Los Angeles, State of California, and that said co-partnership has a regular and established place of business at San Marino, County of Los Angeles, State of California, all within the Southern District of California, Central Division.

III.

That plaintiffs are informed and believe and therefore allege that Halliburton Oil Well Cementing Company is a corporation organized under the laws of the State of Delaware, and [3] has a regular and established place of business at Los Angeles, in the County of Los Angeles, State of California, within the Southern District of California, Central Division.

IV.

That the grounds upon which this Court's jurisdiction depends is that this is a suit arising under the patent laws of the United States.

V.

That on May 2, 1939 United States Letters Patent No. 2,156,519 were duly and legally issued to plaintiff Cranford P. Walker for an invention in Means for Measuring the Location of Obstructions in

Wells, and since that date plaintiff Cranford P. Walker has been and still is the owner of those Letters Patent.

VI.

That on June 6, 1939 United States Letters Patent No. 2,161,733 were duly and legally issued to plaintiff Cranford P. Walker for an invention in Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells, and Letters Patent were duly and legally reissued to plaintiff Cranford P. Walker as Reissue Letters Patent No. 21,383 on March 5, 1940, and since March 5, 1940, plaintiff Cranford P. Walker has been and still is the owner of those Letters Patent and Reissue Letters Patent.

VII.

That on July 30, 1940 United States Letters Patent No. [4] 2,209,944 were duly and legally issued to plaintiff Cranford P. Walker for an invention in Method of Measuring Location of Obstructions in Deep Wells, and since that date plaintiff Cranford P. Walker has been and still is the owner of those Letters Patent.

VIII.

That by agreements in writing between the said Cranford P. Walker and the Depthograph Company, a co-partnership, said agreements being dated, respectively, July 6, 1939, March 25, 1940, June 1, 1939 and August 27, 1940, the said Depthograph Company, a co-partnership, is the sole and exclusive licensee under said Letters Patent Nos. 2,156,510,

2,209,944 and Reissue Letters Patent No. 21,383, all as will more fully and at large appear by the originals of said license agreements, or by duly certified copies thereof, ready to be produced in court as may be requested.

IX.

That defendant Halliburton Oil Well Cementing Company has for a long time past and still is infringing each of said Letters Patent Nos. 2,156,510, 2,209,944 and Reissue Letters Patent No. 21,383, by making, selling, leasing and using apparatus for measuring the location of obstructions in wells and by practicing the methods of measuring location of obstructions in deep wells and determining fluid density, fluid pressure and production capacity of oil wells embodying the patented inventions, all within the Southern District of California and elsewhere, and will continue to do so unless enjoined by this Court. [5]

X.

That plaintiffs have given notice to defendant of its said infringement.

Wherefore, Plaintiffs pray:

(a) That a preliminary and final injunction issue against further infringement of said United States Letters Patent Nos. 2,156,519, 2,209,944 and Reissue Letters Patent No. 21,383, by defendant and those controlled by defendant.

(b) That defendant be ordered and decreed to account to plaintiffs for all gains, profits and advantages realized by defendant as a result of said

infringement of United States Letters Patent Nos. 2,156,519, 2,209,944 and Reissue Letters Patent No. 21,383, and that in addition to said gains, profits and damages to be so accounted for, the damages sustained by plaintiffs as a result of said infringement of said United States Letters Patent aforesaid.

(c) That plaintiffs may have and recover from defendant the costs to be taxed and have execution therefor.

(d) That plaintiffs may have such other and further relief in the premises as equity and good conscience may require.

HAROLD W. MATTINGLY
Attorney for Plaintiffs
720 Pacific Finance Bldg.
621 South Hope Street
Los Angeles, California
MA 1137

[Endorsed]: Filed Jul. 16, 1941. [6]

[Title of District Court and Cause.]

BILL OF PARTICULARS

Comes now plaintiffs, by their attorney, and in response to defendant's motion in that behalf, furnishes their Bill of Particulars pursuant to Rule 12 (e) of the Rules of Civil Procedure, as follows:

I.

Plaintiffs are not fully advised as to all of the methods and apparatus employed by the defendant

but as now advised, plaintiffs will rely upon and assert as infringing the Letters Patent in suit, each and every of the methods employed by defendant to perform any and all of the following: To measure the location of fluid levels and other obstructions and apparatus in oil wells, to determine subsurface pressures, to determine bottom-hole pressures, to determine fluid gradients, to determine production capacities, to determine well potentials and to determine productivity index of oil wells of the character referred to in the attached pamphlets entitled "An Echo Writes the Fluid Level of Your Well" marked plantiffs' Exhibit 1, and "Halliburton 'Echo-Meter' for accurate fluid level determinations", marked plaintiffs' Exhibit 2, and of the character referred to in the attached data sheets entitled "Echometer Field Data" and "Subsurface Pressure Test Data Potential Determination for Pumping Wells", marked plaintiffs' Exhibit 3, Sheets 1 to 5, respectively, and the apparatus employed by defendant to perform such mehods [7] of the character pictured in and referred to in plaintiffs' Exhibit 1.

II.

Plaintiffs are not fully informed as to the details of the apparatus employed by defendant for measuring the location of fluid levels and other obstructions but as at present advised will rely upon and assert as infringing the Letters Patent in suit the apparatus as recited in Paragraph I hereof.

III.

As at present advised, plaintiffs will rely upon and assert the following:

(a) As to defendant's method of measuring the location of fluid levels and other obstructions and apparatus in oil wells, Claims 1, 2, 3, 4, 5, 6, 7, 8 and 9 of Letters Patent No. 2,209,944, and Claims 1, 12, 13, 14, 15 and 17 of Letters Patent No. 2,156,519.

(b) As to defendant's method of determining subsurface pressures and bottom-hole pressures, Claims 5, 7, 9 and 10 of Reissue Letters Patent No. 21,383, and as to defendant's [8] step of measuring the fluid levels utilized in this method, those claims of Letters Patents Nos. 2,209,944 and 2,156,519 specified in subparagraph (a) hereof.

(c) As to defendant's method of determining fluid densities and fluid gradients, Claims 1, 2, 3, 4 and 5 of Reissue Letters Patent No. 21,383, and as to the step of measuring the fluid levels utilized in the method those claims of Letters Patent Nos. 2,209,944 and 2,156,519 specified in sub-paragraph (a) hereof.

(d) As to defendant's method of determining production capacities, well potentials and the productivity index of wells, Claims 8 and 11 of Reissue Letters Patent No. 21,383 and as to the steps of fluid densities or gradients utilized in the method, Claims 1, 2, 3, 4 and 5 of Reissue Letters Patents No. 21,383 and as to the step of measuring fluid levels utilized in this method, the claims of Letters

Patent No. 2,209,944 and No. 2,156,519, specified in sub-paragraph (a) hereof.

Dated at Los Angeles, California, this 21st day of October, 1941.

HAROLD W. MATTINGLY
Attorney for Plaintiffs.

A copy of the foregoing Bill of Particulars has been handed to Frank L .A. Graham, 811 West 7th Street, Los Angeles, California, attorney for defendant, on this 22nd day of October, 1941.

HAROLD W. MATTINGLY

[Endorsed]: Filed Oct. 22, 1941. [9]

(Copy)

[Title of District Court and Cause.]

AMENDED ANSWER OF DEFENDANT

Now comes the Defendant, Halliburton Oil Well Cementing Company, leave of court being first had thereto, and files this its Amended Answer to the Complaint herein, and says:

I.

Answering paragraph I of the Complaint, defendant is without knowledge or information sufficient to form a belief as to the truth of the allegation that Cranford P. Walker was and is a citizen, inhabitant and resident of San Marino, County of

Los Angeles, State of California and, therefore, denies the same.

II.

Answering paragraph II of the Complaint, defendant is without knowledge or information sufficient to form a belief as to the truth of the allegation that Cranford P. Walker, D. A. Walker, Robert P. Miller and Milo C. Ketchum are doing business as Depthograph Company, that they all reside in the County of Los Angeles, State of California; that the Depthograph Company is a co-partnership and that it has a regular and established place of business in the County of Los Angeles, State of California, and, therefore denies the same. [10]

III.

Answering paragraph III of the Complaint, defendant admits that the Halliburton Oil Well Cementing Company is a corporation organized under the laws of the State of Delaware and admits that it has a regular and established place of business at Los Angeles, County of Los Angeles, State of California, within the Southern District of California, Central Division.

IV.

Answering paragraph IV of the Complaint, defendant admits that this is an action for infringement of letters patent of the United States and defendant admits the jurisdiction of this Honorable Court.

V.

Answering paragraph V of the Complaint, defendant admits that Letters Patent No. 2,156,519 was issued to plaintiff, Cranford P. Walker on May 2, 1939, but denies that the same was duly and legally issued. Defendant is without knowledge or information sufficient to form a belief as to the truth of the allegation that Cranford P. Walker is the owner of said patent and, therefore denies the same.

VI.

Answering paragraph VI of the Complaint, defendant admits that Letters Patent No. 2,161,733 issued to Cranford P. Walker on June 6, 1939, but denies that the same was duly and legally issued. Defendant admits that Letters Patent No. 2,161,733 was reissued to Cranford P. Walker as Reissue No. 21,383, on March 5, 1940, but denies that the same was duly and legally reissued. Defendant is without knowledge or information sufficient to form a belief as to the truth of the allegation that Cranford P. Walker is the owner of said reissue letters patent, and therefore, denies the same. [11]

VII.

Answering paragraph VII of the Complaint, defendant admits that Letters Patent No. 2,209,944 issued to Cranford P. Walker on July 30, 1940, but denies that the same was duly and legally issued. Defendant is without knowledge or information sufficient to form a belief as to the truth of the

allegation that Cranford P. Walker is the owner of said patent and, therefore, denies the same.

VIII.

Answering paragraph VIII of the Complaint defendant is without knowledge of any agreement between Cranford P. Walker and the Depthograph Company; is without knowledge or information sufficient to form a belief as to the truth of the allegation that the Depthograph Company is a copartnership; or that the Depthograph Company is the sole and exclusive licensee under Letters Patent No. 2,156,519, No. 2,209,944 and Reissue Patent No. 21,383 and, therefore, denies the same.

IX.

Answering paragraph IX of the Complaint, defendant admits that it has made, sold, leased and used apparatus for measuring the location of obstructions in wells and admits that it has practiced methods of measuring the location of obstructions in wells and defendant admits that it has determined fluid density, fluid pressure and production capacity of oil wells within the Southern District of California and elsewhere; but denies that it has infringed the claims of any of said letters patent, within the Southern District of California or elsewhere, and denies that it will do so unless enjoined by this Honorable Court.

X.

Answering paragraph X of the Complaint, defendant denies that plaintiff has given due notice

of alleged infringement of the letters patent mentioned in the Complaint. [12]

With reference to the Bill of Particulars filed herein by the plaintiff on or about the 21st day of October, 1941, defendant says:

XI.

In answer to paragraph I of the Bill of Particulars, defendant admits that it measures the location of fluid levels and other obstructions and apparatus in oil wells, to determine sub-surface pressures, to determine bottom hole pressures, to determine production capacities, to determine well potentials and to determine productivity index of oil wells, of the character referred to in plaintiff's Exhibits 1 and 2 attached to said Bill of Particulars, but denies that the methods disclosed and described in said exhibits or any methods or apparatus employed by defendant in any way infringe the claims of any of the letters patent here in suit. Defendant admits that in a few isolated instances, employees of defendant have determined fluid gradient, as, for example, in plaintiff's Exhibit #3 attached to said Bill of Particulars, and as alleged in paragraph I thereof, but denies that the method thus used to determine fluid gradient is an infringement of the claims of any of the Letters Patent here in suit. Defendant alleges that the determination of fluid gradient to the best of its knowledge and belief, has only been made long prior to the filing of the Complaint herein by employees of defendant only in ten (10) wells; that to the best of

the knowledge and belief of defendant, no charge was made for such determination and no profit derived therefrom by defendant.

XII.

Answering paragraph II of the Bill of Particulars, defendant admits that it has used the apparatus shown and described in plaintiff's Exhibits 1 and 2 accompanying the Bill of Particulars, but denies that said apparatus is an infringement of the claims of any of the letters patent here in suit.

[13]

XIII.

(a) Answering paragraph III (a) of the Bill of Particulars, defendant denies that its method of measuring the location of fluid levels and other obstructions and apparatus in oil wells is in infringement of claims 1 to 9 inclusive, of Letters Patent No. 2,209,944 and of claims 1, 12, 13, 14, 15 and 17 of Letters Patent No. 2,156,519.

(b) Answering paragraph III (b) of the Bill of Particulars, defendant denies that its method of determining sub-surface pressures and bottom hole pressures is in infringement of claims 5, 7, 9 and 10 of Reissue Letters Patent No. 21,383, and defendant denies that its steps of measuring the fluid levels utilized in its method is in infringement of those claims of Letters Patent Nos. 2,209,944 and 2,156,519 specified in paragraph III (a) of the Bill of Particulars.

(c) Answering paragraph III (c) of the Bill of Particulars, defendant admits that its employees

have, in a few isolated cases, determined fluid density or fluid gradient, but denies that such determinations were in infringement of claims 1 to 5, inclusive, of Reissue Patent No. 21,383. Defendant alleges that the acts involved in said isolated cases are trivial and to the best of knowledge and belief of officers of defendant, were discontinued long prior to the bringing of this suit. Defendant denies that the acts admitted in this paragraph constituted infringement of those claims of Letters Patent No. 2,209,944 and 2,156,519 specified in paragraph III (a) of the Bill of Particulars.

(d) Answering paragraph III (d) of the Bill of Particulars, defendant denies that its method of determining production capacities, well potentials, and the productivity index of wells is in infringement of claims 8 and 11 of Reissue Patent No. 21,383. Defendant denies that the few isolated cases where it has performed the steps of determining fluid densities or gradients were in in- [14] fringement of claims 1, 2, 3, 4 and 5 of Reissue Patent No. 21,383. Defendant denies that the method it employs for measuring fluid levels is in infringement of the claims of Letters Patent 2,209,944 and 2,156,519, specified in paragraph III (a) of the Bill of Particulars.

Further answering the Complaint:

XIV.

Defendant alleges that this action is barred in equity because of unconscionable conduct on the part of plaintiff. Defendant alleges that prior to

any alleged invention of any of the patents in suit, one Paul E. Lehr and one Harold T. Wyatt, patentees of U. S. Patent No. 2,047,974, had, in public use, certain methods and apparatus for measuring well depths, and certain methods and apparatus for determining density of fluid in a well, which methods and apparatus were the same or similar to methods and apparatus asserted to infringe the patents in suit; that plaintiffs have entered into one or more contracts with said Lehr and said Wyatt, the effect of which contract or contracts was intended to be, and is, either by express terms or implied conditions:

(a) To suppress evidence as to the prior public use by Lehr or Wyatt.

(b) To make Lehr and Wyatt adverse or unwilling witnesses for defendant.

(c) To cause Lehr and Wyatt to make laudatory statements as to the alleged inventions of plaintiff and derogatory statements as to their own prior invention, contrary to the facts.

(d) To make Lehr and Wyatt financially interested in the outcome of this lawsuit.

XV.

Defendant alleges that plaintiff has asserted and is asserting in this action, a broad and dominating monopoly wholly un- [15] supported by any invention made by Cranford P. Walker, plaintiff, and wholly unsupported by any invention disclosed by the patents in suit.

XVI.

Defendant alleges upon information and belief, that the letters patent in suit and particularly the claims thereof herein charged to be infringed, and each of them, were so restricted and limited in scope by the procedure in the Patent Office in connection with the applications for the letters patent in suif, divisions, continuations and parent applications, and other applications pending at the same time, relating to the same or similar subject matter, that such claims and each of them, if valid at all, are not entitled to any construction which will include or cover any method or apparatus manufactured, sold or used by defendant; wherefore, defendant denies infringement of any of the claims of said letters patent.

XVII.

Defendant alleges that the claims of the letters patent in suit herein charged to be infringed, cover mere aggregation or old combinations of elements or method steps, and not new patentable combina-

tions or methods and are, therefore, invalid under the law.

XVIII.

Defendant alleges that the claims of the letters patent in suit herein charged to be infringed, distinguish over the prior art existing at the time of the alleged inventions only by the substitution of known equivalent elements or steps of the prior art, and are, therefore, invalid.

XIX.

Defendant alleges that the claims of Letters Patent No. 2,156,519 charged to be infringed by this defendant, are invalid and void for the following reasons: [16]

(a) That the apparatus described and claimed in each of claims 1, 12, 13, 14, 15, and 17, here in suit, or material and substantial parts thereof, were patented or described in printed publications prior to the alleged invention or discovery thereby by Cran-

ford P. Walker, or more than two years prior to his application for said letters patent as follows:

U. S. Patents		Date
Batcheller	602,422	April 19, 1898
Fessenden	1,217,585	Feb. 27, 1917
Fessenden	1,240,328	Sept. 18, 1917
Tucker	1,351,356	Aug. 31, 1920
Behm	1,649,378	Nov. 15, 1927
Williams	1,671,262	May 29, 1928
Dorsey	1,730,411	Oct. 8, 1929
Taylor	1,847,636	March 1, 1932
Smith	2,008,934	July 23, 1935
Gilmore	2,021,774	Nov. 19, 1935
Lehr et al	2,047,974	July 21, 1936
Kunze	2,116,523	May 10, 1938
Scott	2,173,426	Sept. 19, 1939
Halliburton	2,201,311	May 21, 1940

British patent to William S. Tucker No. 138,-368 for "Improvements in and Relating to Microphones", complete accepted May 22, 1917 and published January 20, 1920;

British patent of addition to William S. Tucker, No. 195,199 for "Improvements in and Relating to Hot Wire Microphones", complete accepted March 29, 1923;

An article entitled "Hot-Wire Microphone and its Application to Problems of Sound" by Major W. S. Tucker, of Thames Ditton, England, appearing on pages 121 to 137 inclusive, of the "Journal of the Royal Society of Arts", Vol. LXXI, No. 3659 of January 5, 1923.

and also other patents and printed publications, the names, numbers, dates and authors of which are not at present known to defendant, but which, when ascertained, defendant prays leave to add hereto.

(b) That the apparatus described and claimed in each of claims 1, 12, 13, 14, 15 and 17 of Letters Patent No. 2,156,519, in suit, do not involve inven-

tion over the prior art cited in paragraph [17] XIX (a) hereof but represent, at most, the exercise of mere skill in the art.

(c) That Cranford P. Walker was not the original and first inventor or discoverer of the things defined in claims 1, 12, 13, 14, 15 and 17, of Letters Patent No. 2,156,519 or of any material or substantial part thereof, but prior to the alleged invention thereof by Cranford P. Walker, the same were, if invention be involved therein, invented by or known to the patentees listed in paragraph XIX (a) hereof, at the addresses given in the Letters Patent or publications and also by others not now known to defendant but which, when ascertained, defendant prays leave to add hereto.

XX.

Defendant alleges that the matter purported to be covered by Letters Patent No. 2,156,519 is not a statutory subject of a patent, and that the same is, therefore, invalid and void.

XXI.

Defendant alleges that claims 1, 12, 13, 14, 15 and 17 of Patent No. 2,156,519 are not distinct in that they do not particularly point out or distinctly claim the part, improvement or combination which the patentee claims as his invention, as required by law, and that, therefore, said claims are invalid and void.

XXII.

Defendant alleges that the claims of Letters Patent No. 2,209,944 charged to be infringed by this

defendant, are invalid and void for the following reasons:

(a) That the methods described and claimed in each of the claims thereof, or material and substantial parts thereof, were patented or described in print- [18] ed publications prior to the alleged invention or discovery thereof by Cranford P. Walker, or more than two years prior to this application for said letters patent as follows:

The Prior Art Cited in Paragraph XIX (a) Hereof, and also other patents and printed publications, the names, numbers, dates and authors of which are not at present known to defendant but, which, when ascertained, defendant prays leave to add hereto.

(b) That the method described and claimed in each of the claims of Letters Patent No. 2,209,944 in suit, do not involve invention over the prior art cited in paragraph XIX (a) hereof, but represent, at most, the exercise of mere skill in the art.

(c) That Cranford P. Walker was not the original and first inventor or discoverer of the method patented in Letters Patent No. 2,209,944, or of any material or substantial part thereof; but prior to the alleged invention thereof by Cranford P. Walker, the same were, if invention be involved therein, invented by or known to the patentees listed in paragraph XIX (a) hereof, at the addresses given in the patents and also by others not now known to defendant, but which, when ascertained, defendant prays leave to add hereto.

XXIII.

Defendant alleges that the matter purported to be covered by the claims of Letters Patent No. 2,209,944 is not a statutory subject of a patent, and that the same is, therefore, invalid and void. [19]

XXIV.

Defendant alleges that the claims of Letters Patent No. 2,209,944 are not distinct, in that they do not particularly point out or distinctly claim the steps, improvement or part of the method which the patentee claims as his invention, as required by law, and that, therefore, said claims are invalid and void.

XXV.

Defendant alleges that said Letters Patent No. 2,209,944 is utterly void because granted in violation of R.S. Sec. 4886 (U.S.C. title 35 sec. 21), the method described and claimed in said Patent No. 2,209,944, having been in public use in the United States more than two years prior to the date of application (Serial No. 296,781) on which said Letters Patent No. 2,209,944 was granted.

Defendant alleges further that said application (Serial No. 296,781) on which said Letters Patent No. 2,209,944 was granted, was filed September 25, 1939.

Defendant alleges further that the identical method of said Letters Patent No. 2,209,944 was put in public use in the United States by Cranford P. Walker, patentee, on March 6, 1937 on a well owned by the Rio Grande Oil Company at or

near Maricopa, California and that subsequently, but more than two years prior to said filing date of September 25, 1939, the method identical with that of said Letters Patent No. 2,209,944 was placed in public use in the United States, on hundreds of other wells, by said Cranford P. Walker.

Accordingly, defendant alleges that said Cranford P. Walker abandoned the alleged invention of said Letters Patent 2,209,944 by not applying for a patent on it during the time allowed by the statutes for such an application.

XXVI.

Defendant alleges that said application (Serial No. 296,781) which matured into Letters Patent No. 2,209,944 was filed in violation of the Statutes of the United States in effect on its filing [20] date, September 25, 1939 and that the same is, therefore, wholly void; and particularly in that said application is in violation of the repeal (By H.R. 6874, effective August 9, 1939) of R.S. Sec. 4897 (U.S.C. title 35, sec. 38); that said application (Serial No. 296,781) is an application for patent for the same alleged invention or discovery upon which said Cranford P. Walker had previously applied for patent, by an application Serial No. 270,865, filed April 29, 1939, which previous application had been allowed on September 14, 1939 (after the repeal of R.S. 4897) with notice to said Cranford P. Walker that it could not be renewed; that said Cranford P. Walker, in disregard of said notice and in evasion of the repeal of the statute which for-

merly had authorized such renewal of application for patent (R.S. Sec. 4897), did nevertheless renew his application for patent (Serial No. 296,781) and obtained Patent No. 2,209,944 here in suit, in violation of the law.

XXVII.

Defendant alleges that the claims of Letters Patent Reissue No. 21,383, charged to be infringed by this defendant, are invalid and void for the following reasons:

(a) That the methods described and claimed in each of claims 1 to 5, inclusive, and 7 to 11, inclusive, or material and substantial parts thereof, were patented or described in printed publications prior to the alleged invention or discovery thereof by Cranford P. Walker, or more than two years prior to his application for the original patent upon which said reissue was granted, as follows:

U. S. Patents	Date
Batcheller—602,422	April 19, 1898
Lehr—2,047,974	July 21, 1936

[21]

PUBLICATIONS

An article entitled "A Method of Determining Production Allowances in Prorated Fields", by H. D. Wilde, Jr. and T. V. Moore, appearing on pages 71 to 77 of Production Bulletin No. 207 of the American Petroleum Institute, published June 30, 1931.

An article entitled "Sub-Surface Pressures in Oil Wells", by D. G. Hawthorn, appearing on pages 148 to 169 of Volume 103 of the Transactions of the American Institute of Mining and Metallurgical Engineers, published in 1933.

An article entitled "Bottom Hole Pressure Bomb Aids in Selection of Equipment for Wells", by Harold Ihrig, appearing on page 32 of the Oil and Gas Journal, of October 17, 1935.

An article entitled "New Apparatus for Precise Measurement of Bottom Hole Pressures", by S ı-ley Gill, appearing on pages 27 to 32 of "The Oil Weekly" for April 4, 1932.

An article entitled "Reservoir Pressures in the Hobbs Field, New Mexico", by R. S. Christie, of

Longview, Texas, appearing on pages 342-352 inclusive, of "Petroleum Development and Technology" copyright 1932 by American Institute of Mining and Metallurgical Engineers;

An article entitled "Determination and Application of Depth Pressures in the Yates Field" by Dale Nix of Iraan, Texas, appearing on pages 353 to 366 inclusive, of "Petroleum Development and Technology", copyright 1932 by American Institute of Mining and Metallurgical Engineers;

An article entitled "Bottom-Hole Pressures in Oil Wells" by C. V. Milikan of Tulsa, Oklahoma and Carroll V. Sidwell of Seminole, Oklahoma, appearing on pages 194 to 205 inclusive, of "Petroleum Development and Technology" copyright 1931 by American Institute of Mining and Metallurgical Engineers;

An article entitled "Density of Oil-Gas Columns from Well Data" by William V. Vietti, of Wink, Texas, appearing on pages 215 to 220 inclusive of "Petroleum Development and Technology" copyright 1931 by American Institute of Mining and Metallurgical Engineers.

and also other patents and printed publications, the names, numbers, dates and authors of which are not at present known to defendant but, which, when ascertained, defendant prays leave to add hereto.

(b) That the methods described and claimed in each of claims 1 to 5, inclusive, and 7 to 11, inclusive, of Letters Patent Reissue No. 21,383 in suit, do not involve invention over the prior art cited in paragraph XXVII (a) hereof, but represent, at most, the exercise of mere skill in the art.

(c) That Cranford P. Walker was not the original and first inventor or discoverer of the things [22] patented by Reissue No. 21,383, or of any material or substantial part thereof, but prior to the alleged invention thereof by Cranford P. Walker, the same were, if invention be involved therein, invented by or known to the patentees or authors listed in paragraph XXVII (a) hereof, at the addresses given in the letters patent and publications and also by others not now known to defendant

but, which, when ascertained, defendant prays leave to add hereto.

XXVIII.

Defendant alleges that the matter covered by Letters Patent Reissue No. 21,383 is not a statutory subject of a patent, and that the same is, therefore, invalid and void.

XXIX.

Defendant alleges that claims 1 to 5, inclusive, and 7 to 11, inclusive, of Letters Patent Reissue No. 21,383 are not distinct in that they do not particularly point out and distinctly claim the steps, improvements or part of the method, which the patentee claims is his invention, as required by law, and that, therefore, said claims are invalid and void.

XXX.

Defendant alleges that Letters Patent Reissue No. 21,383 is invalid and void because the original Patent No. 2,161,733 was surrendered and reissued in the absence of any statutory foundation therefor.

XXXI.

Defendant alleges that there was no inadvertence, accident or mistake in failing to claim in original Patent No. 2,161,733, all that is claimed in Reissue Patent No. 21,383, and that, therefore, said reissue is invalid and void. [23]

XXXII.

Defendant alleges that Letters Patent Reissue No. 21,383 in suit, covers a different invention from any which original Patent No. 2,161,733 shows was intended to be secured thereby and, that said reissue is, therefore, invalid and void.

XXXIII.

Defendant alleges that the Commissioner of Patents exceeded his legal authority in granting Letters Patent Reissue No. 21,383, and that the same is, therefore, invalid and void.

XXXIII-A

Further answering said complaint defendant alleges that Cranford P. Walker the alleged patentee of the patents in suit is not the original or first inventor or discoverer of the alleged inventions or any material or substantial part thereof purported to be covered by the claims in said Letters Patents in suit or any of them in that the said Letters Patents and each of them is invalid and void for the following reasons:

(a) Because that which is alleged to be patented by said Letters Patents and each of them and particularly that which is described in the claims thereof and all material and substantial party thereof had been in public use more than two years prior to the filing of the respective applications for said Letters Patents in suit thereof by the said Cranford P. Walker, by each of the persons whose names, residences and places of public use are as follows:

Harold T. Wyatt, 515 No. Reeder Street, San Dimas, California; at Signal Hill and Dominguez Oil Fields in Los Angeles County, State of California;

Paul E. Lehr, 219 Monte Vista Drive, Bakersfield, California; at Signal Hill and Dominguez Oil Fields in Los Angeles County, State of California, and at Ventura, California;

Shell Oil Company, Inc., at Signal Hill and Dominguez Oil Fields in Los Angeles County, State of California; and

Union Oil Company of California at Dominguez Oil Field, Los Angeles County, State of California.

(b) Because that which is alleged to be patented by said Letters Patents and each of them and particularly that which is described in the claims thereof and all material and substantial parts thereof had been known or used in the United

States more than two years prior to the filing of the respective applications for said Letters Patents in suit or prior to the alleged invention thereof by the said Cranford P. Walker, by each of the persons whose names and residences are given in paragraph (a) above.

XXXIV.

Defendant denies that it has used any method or any apparatus within the Southern District of California or elsewhere which infringes upon any of the said letters patent or any claim thereof.

Wherefore, defendant prays that said Letters Patent Nos. 2,156,519, 2,209,944 and Reissue No. 21,383 be declared invalid and of no force and effect; that defendant be declared not to infringe the aforesaid letters patent, or any claims thereof; that the cost herein be taxed against the plaintiff and that the Complaint herein be dismissed, and for such other and different relief as the Court may deem just and equitable.

FRANK L. A. GRAHAM,
811 West Seventh Street, Los Angeles, California.
EARL BABCOCK,
Duncan, Oklahoma.
Attorneys for Defendant.

State of California,
County of .....—ss.

.....

being by me first duly sworn, deposes and says: That he is.....

.....

.....

in the foregoing and above entitled action: that he has.....read the foregoing.....

.....

and knows the contents thereof; and that the same is true of h.....own knowledge, except as to the matters which are therein stated upon h.....information or belief, and as to those matters that he believes it to be true.....

.....

Subscribed and Sworn to before me this.....day of....., 19.....

.....

.....

Notary Public in and for said County and State.

[Notarial Seal]

[Endorsed]: Filed Apr. 13, 1942. [24]

[Title of District Court and Cause.]

FINDINGS OF FACT AND CONCLUSIONS OF LAW

This cause having come on regularly to be heard in open court upon the issues raised by the Bill

of Complaint, Answer, Amended Answer and Amendment to Amended Answer and evidence, oral, documentary and physical, having been introduced and this Court having fully considered the same, together with the arguments of counsel, the Court makes the following findings of fact and conclusions of law, to-wit:

FINDINGS OF FACT

1. This is a suit involving the questions of validity and infringement of United States Letters Patent No. 2,156,519, No. 2,209,944 and Reissue No. 21,383, granted to Plaintiff, Cranford P. Walker, who is the owner of said Letters Patent and under which Depthograph Company, a co-partnership, is the exclusive licensee.

2. Plaintiffs reside within the County of Los Angeles, State of California and within the Southern District of California, Central Division.

3. Defendant, Halliburton Oil Well Cementing Company, a Delaware corporation, has a regular and established place of business at Los Angeles, County of Los Angeles, State of California and within the Southern District of California, Central Division.

4. The patents in suit are improvement patents and relate to means and methods for measuring the location of obstructions [25] and fluid levels in wells and in using the measurements thus obtained for making calculations of conditions in the well.

5. Prior to the patents in suit it was not new to fire a gun into a pipe and mechanically record

he echo from an obstruction in the pipe and it was not new to inject into a well casing a charge of gas from a cylinder of gas under pressure and record electrically the echoes from obstructions in the well.

6. Patent No. 2,156,519 is an apparatus patent and the apparatus disclosed includes mechanism for creating in the well a pressure wave caused by the sudden introduction of pressure into the well casing or the sudden release of pressure from the casing, a tuned acoustical resonator for accenting reflections from tubing collars or other apparatus or equipment in the well which diminishes or enlarges the annular space in the well at known regular intervals, a diaphragm actuated by pressure caused by the echoes and a mechanical, optical translating and recording mechanism for recording the echoes upon a tape together with mechanism for recording on the tape time intervals. This apparatus differs from and is an improvement over the prior art in the incorporation in such apparatus of a tuned acoustical means which performs the function of a sound filter as described in Claims 1, 13, 14, 15 and 17. This improvement involves invention over the prior art.

7. Walker patent No. 2,209,944 is a method patent and discloses and claims certain methods of determining the locations of obstructions in a well by introducing into the well a pressure [26] wave and the recording of echoes from the various known obstructions or partial obstructions in the well and calculating from information so acquired the lo-

cation of the obstructions. The novelty of this patent consists only in the performance of mental steps such as "counting," "observing," "computing" and "comparing", which do not involve invention.

8. The Walker Reissue Patent No. 21,383 is a method patent and discloses and claims methods of determining fluid density, fluid pressure and production capacity of an oil well by measuring two fluid levels and the pressure thereon and calculating using such information. The claimed methods differ from the prior art in the steps of measuring a fluid level under one condition of gas pressure in the well, measuring the gas pressure on the fluid, altering said gas pressure and again measuring the fluid level and gas pressure on the fluid, and from data thus obtained calculating the fluid density, fluid pressure or production capacity. These methods involve invention over the prior art.

9. Defendant manufactures and uses means for measuring the location of obstructions and fluid levels in wells and uses the measurements thus obtained in making calculations of conditions in the well. Defendant's apparatus consists of a gun and an electrical recording system composed of a hot wire microphone, an amplifier and a recorder, and in addition, an electrical filter incorporated in the amplifier circuit. The electrical filter is the equivalent of the acoustical tuned resonator of Patent No. 2,156,519 and when [27] the filter or an equivalent is used defendant's apparatus infringes

Claims 1, 13, 14, 15 and 17 of Patent No. 2,156,519 in suit.

10. Defendant's methods of determining pressure below the fluid surface, determining fluid gradient or density of the fluid in the fluid column or determining the production capacity of a well which involves the steps of taking two gas pressure measurements and two corresponding fluid level measurements and comparing them arithmatically or graphically is an infringement of the claims of Reissue Patent No. 21,383.

CONCLUSIONS OF LAW

I.

This is a case arising under Patent Laws of the United States and this Court has jurisdiction of the parties and the subject-matter.

II.

Plaintiff, Cranford P. Walker, is the owner of United States Letters Patents 2,156,519; 2,209,944 and Reissue 21,383 in suit and plaintiff, Depthograph Company, a co-partnership, is the owner of the exclusive license rights thereunder.

III.

That Letters Patent 2,156,519 is good and valid in law as to each of Claims 1, 13, 14, 15 and 17 in suit.

IV.

That each of Claims 1, 13, 14, 15 and 17 of Letters Patent No. 2,156,519 has been infringed by the defendant. [28]

V.

That Reissue Letters Patent No. 21,383 is good and valid in law as to each of the claims thereof.

VI.

Each of the claims of said Walker Reissue Patent No. 21,383 has been infringed by defendant.

VII.

Walker patent No. 2,209,944 is invalid as to each of the claims thereof as defining methods which do not involve invention and are unpatentable.

VIII.

Plaintiffs are entitled to a permanent injunction against further infringement of Letters Patent No. 2,156,519 and Reissue Letters Patent No. 21,383 and to recover profits and damages arising out of past infringement.

Apr. 22, 1943.

PEIRSON M. HALL,
Judge.

Approved as to Form.

HAROLD W. MATTINGLY,
ROBERT W. FULWIDER,
Attorneys for Plaintiffs.
FRANK L. A. GRAHAM,
EARL BABCOCK,
Attorneys for Defendant.

[Endorsed]: Filed Apr. 22, 1943. [29]

District Court of the United States, Southern District of California, Central Division

No. 1655-PH Civil

CRANFORD P. WALKER, et al.,

Plaintiffs,

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY,

Defendant. [30]

DECREE

This cause having come on to be heard and evidence, oral, documentary and physical, having been introduced and this Court having fully considered the same, together with arguments of counsel, It Is Ordered, Adjudged and Decreed as Follows:

I.

That plaintiff Cranford P. Walker is the owner of United States Letters Patents Nos. 2,156,519, 2,209,944 and Reissue 21,383, and plaintiff Depthograph Company, a co-partnership, is the owner of the exclusive license rights thereunder, and said plaintiffs are the owners of all rights of action and recovery for infringement of said Letters Patents.

II.

That United States Letters Patent No. 2,156,519 is good and valid in law and particularly as to Claims 1, 13, 14, 15 and 17 thereof.

III.

That United States Reissue Letters Patent No. 21,383 is good and valid in law as to each of the claims thereof.

IV.

That United States Letters Patent No. 2,209,944 is invalid as to each of the claims thereof as defining methods which do not involve invention and which are not patentable. [31]

V.

That the defendant Halliburton Oil Well Cementing Company has infringed said United States Letters Patent No. 2,156,519 and particularly Claims 1, 13, 14, 15 and 17 thereof.

VI.

That the defendant Halliburton Oil Well Cementing Company has infringed United States Reissue Letters Patent No. 21,383 and particularly each and every of the claims thereof.

VII.

That a permanent injunction issue out and under the seal of this Court directed to the defendant Halliburton Oil Well Cementing Company, its agents, servants, employees, associates and attorneys and those in active concert and participating with them or any of them, permanently enjoining and restraining them and each of them from directly or indirectly in any manner making, using or selling or causing to be made, used or sold any appara-

tus for measuring the location of fluid levels or obstructions in wells covered by Claims 1, 13, 14, 15 and 17 of said United States Letters Patent No. 2,156,519, and permanently enjoining and restraining them and each of them from directly or indirectly in any manner infringing U. S. Letters Patent Number Reissue 21,383 by using, practicing or selling or causing to be used, practiced or sold any method for determining pressure in the fluid column of a well, or determining density of the fluid in the fluid column of a well, or determining the production capacity, productivity index or potential of a well which includes the steps of taking two gas [32] pressure measurements and two corresponding fluid level measurements and comparing them.

VIII.

That the plaintiffs recover from the defendant Halliburton Oil Well Cementing Company the profits made by said defendant and the damages suffered by plaintiffs arising out of or accruing from said infringement by the defendant Hall burton Oil Well Cementing Company, and that in the event plaintiffs and defendant cannot agree upon the amount of such profits and damages, then upon application of plaintiffs to this Court, this Court will appoint a Special Master and refer this cause to him to ascertain such profits and damages and to report the same to this Court.

IX.

That plaintiffs and defendant must each bear its own costs.

Apr. 22, 1943.

PEIRSON M. HALL,
United States District Judge.

Approved as to Form.

HAROLD W. MATTINGLY,
ROBERT W. FULWIDER,
Attorneys for Plaintiffs.
FRANK L. A. GRAHAM,
EARL BABCOCK,
Attorneys for Defendant.

Judgment entered Apr. 22, 1943. Docketed April 22, 1943. C. O. Book 16, Page 240. Edmund L. Smith, Clerk. By J. M. Horn, Deputy.

[Endorsed]: Filed Apr. 22, 1943. [33]

[Title of District Court and Cause.]

NOTICE OF APPEAL

Notice is hereby given that Halliburton Oil Well Cementing Company, defendant herein, hereby appeals to the Circuit Court of Appeals for the Ninth Circuit from the Judgment and Decree entered in this action on the 22nd day of April, 1943, insofar as said Judgment and Decree holds Letters Patent of the United States No. 2,156,519 and Reissue Letters Patent No. 21,383 valid and infringed, and

from the granting of the injunction and accounting thereon.

Dated this 12th day of May, 1943, Los Angeles, California.

FRANK L. A. GRAHAM,
WILLIAM R. GRAHAM,
EARL BABCOCK,
Attorneys for Defendant.

[Endorsed]: Filed & mailed copy to Harold W. Mattingly, Attorney for Plf. May 12, 1943, 1:40 P. M. Edmund L. Smith, Clerk. By John A. Childress, Deputy Clerk. [34]

[Title of District Court and Cause.]

COST BOND ON APPEAL

Than we, Halliburton Oil Well Cementing Company, a Delaware corporation, principal and Fidelity and Deposit Company of Maryland, as surety, are held and firmly found unto Cranford P. Walker; and Cranford P. Walker, D. A. Walker, Robert F. Walker and Milo C. Ketchum doing business as Depthograph Company, plaintiffs in the above named and numbered cause, in the sum of Two Hundred and Fifty ($250.00) Dollars, lawful money of the United States, to be paid to them, their successors and assigns; to which payment well and truly be made, we bind ourselves and each of us,

jointly and severally, and each of our successors and assigns by these present. [35]

Executed and Dated this 1st day of June, 1943, A.D.

Whereas, the above named Halliburton Oil Well Cementing Company, a Delaware Corporation, has prosecuted an appeal to the Honorable United States Circuit Court of Appeals for the Ninth Circuit to reverse the Decree of the District Court for the Southern District of California in the above entitled cause;

Now, Therefore, the condition of this obligation is such that if the above named Halliburton Oil Well Cementing Company, a Delaware Corporation, shall prosecute the said appeal to effect and answer all costs if it fails to make good its plea, then this obligation shall be void, otherwise to remain in full force and effect.

HALLIBURTON OIL WELL CEMENTING COMPANY,
By A. D. STODDARD,
Vice-President.
Attest: L. D. CAMBELL,
Secretary.

FIDELITY AND DEPOSIT COMPANY OF MARYLAND.
By D. E. GORTON,
Attorney in Fact.
Attest: S. M. SMITH,
Agent.

Approved: PEIRSON M. HALL,
Judge.

June 7, 1943.

State of California,
County of Los Angeles—ss.

On this 1st, day of June, 1943, before me, Theresa Fitzgibbons, a Notary Public, in and for the said County of Los Angeles, State of California, residing therein, duly commissioned and sworn, personally appeared D. E. Gorton, known to me to be the Attorney-in-Fact, and S. M. Smith, known to me to be the Agent of the Fidelity and Deposit Company of Maryland, the Corporation that executed the within instrument, and acknowledged to me that they subscribed the name of the Fidelity and Deposit Company of Maryland thereto and their own names as Attorney-in-Fact and Agent, respectively.

[Seal] THERESA FITZGIBBONS,
Notary Public in and for the County of Los Angeles, State of California.
My Commission Expires May 3, 1946.

[Endorsed]: Filed June 7, 1943. [36]

[Title of District Court and Cause.]

STATEMENT OF POINTS ON WHICH DEFENDANT-APPELLANT INTENDS TO RELY ON APPEAL

Comes now the Defendant-Appellant in the above entitled cause and, in accordance with Rule 75 (d) of the Federal Rules of Civil Procedure, states that on the appeal the following points will be relied on:

1. The District Court erred in adjudging United States Letters Patent 2,156,519 good and valid in law and particularly as to claims 1, 13, 14, 15 and 17 thereof.

2. The District Court erred in adjudging that the defendant Halliburton Oil Well Cementing Company has infringed United States Letters Patent 2,156,519, and particularly claims [37] 1, 13, 14, 15 and 17 thereof.

3. The District Court erred in finding that the claims of United States Letters Patent 2,156,519 define invention over the prior art.

4. The District Court erred in according United States Letters Patent 2,156,519 a broad range of equivalents, particularly after having found it to be merely an "improvement" patent.

5. The District Court erred in finding that an electrical filter circuit as part of an electrical sound recording system is the equivalent of a mechanical acoustically tuned resonator (a pipe of a particular length) as part of a mechanical recording system.

6. The District Court erred in not finding that the proceedings in the Patent Office estop Plaintiffs from asserting that an electrical filter circuit is the equivalent of an acoustically tuned resonator in the apparatus of United States Letters Patent 2,156,519.

7. The District Court erred in not finding that mechanical acoustically tuned resonators were old and well known in the art prior to United States Letters Patent 2,156,519 and that no invention

was involved in using an acoustically tuned resonator in known mechanical sound recording systems, particularly those of the claims of United States Letters Patent 2,156,519 in suit.

8. Having found that it was old in the art prior to United States Letters Patent 2,156,519 to fire a gun into a pipe and mechanically record the echo from an obstruction in the pipe, and having found that it was also old in the art to inject into a well casing a charge of gas from a cylinder of gas under pressure and record electrically the echoes from obstructions in the well, the District Court erred in finding that the apparatus of United States Letters Patent 2,156,519 differs from and is an improvement [38] over the prior art and particularly in finding that invention is involved in the incorporation into such old apparatus of tuned acoustical means (a pipe of a particular length).

9. The District Court erred in adjudging United States Reissue Letters Patent 21,383 good and valid in law as to each of the claims thereof.

10. The District Court erred in adjudging that defendant Halliburton Oil Well Cementing Company has infringed all or any of the claims of United States Letters Patent Reissue 21,383, and particularly that defendant Halliburton Oil Well Cementing Company should be enjoined from "using, practicing or selling or causing to be used, practiced or sold any method for determining pressure in the fluid column of a well, or determining density of the fluid in the fluid column in a well, or determining the production capacity, productivity

index or potential of a well which includes the steps of taking two gas pressure measurements and two corresponding fluid level measurements and comparing them".

11. The District Court erred in finding that the claims of United States Letters Patent Reissue 21,383 define inventions over the prior art.

12. The District Court erred in not finding that claims 1 to 8, inclusive, of United States Letters Patent Reissue 21,383 are limited to the determination of density of fluid and that any process which does not include the determination of density is not an infringement of said claims 1 to 8, inclusive.

13. The District Court erred in not finding that during the prosecution of the application for United States Letters Patent 2,161,733, (the original of Reissue 21,383) all the claims were intentionally and expressly limited to the determination of density and that claims not limited to the determination of density were cancelled and abandoned and that therefore claims 9, 10 and 11 of Reissue 21,383, must be interpreted as also limited to the [39] determination of density to save them from a holding of invalidity.

14. The District Court erred in not finding that the only novelty in United States Letters Patent Reissue 21,383 resides in the mental or mathematical steps of "dividing", "comparing", "determining", etc. which do not constitute patentable subject matter.

15. The District Court erred in not finding that Plaintiffs, by this action are attempting to assert a broad and dominating monopoly wholly unsupported by any alleged invention made by Cranford P. Walker, Plaintiff, and wholly unsupported by any alleged invention disclosed in United States Letters Patent 2,156,519 and Reissue 21,383, and in not finding that the commercial success enjoyed by Plaintiffs in their Depthograph business is due primarily to the inventions of the prior art and Plaintiffs' exploitation thereof, rather than to the alleged inventions of Patents 2,156,519 and Reissue 21,383 in suit.

FRANK L. A. GRAHAM,
EARL BABCOCK,
Attorneys for Defendant-Appellant.

Service of a copy of this Statement of Points on Which Defendant-Appellant Intends to Rely on Appeal, is hereby acknowledged.

HAROLD W. MATTINGLY,
Attorney for Plaintiffs-Appellees.

June 1, 1943.

[Endorsed]: Filed June 1, 1943. [40]

[Title of District Court and Cause.]

NOTICE OF APPEAL TO THE CIRCUIT COURT OF APPEALS

Notice is hereby given that Cranford P. Walker, and Cranford P. Walker, D. A. Walker, Robert P. Miller and Milo C. Ketchum, doing business as Depthograph Company, a copartnership, plaintiffs above named, hereby appeal to the Circuit Court of Appeals for the Ninth Circuit from that portion of the final judgment entered in this action on the 22nd day of April, 1943 which relates to the validity of United States Letters Patent No. 2,209,944, that portion being Paragraph IV of the Decree.

HAROLD W. MATTINGLY
ROBERT W. FULWIDER
Attorneys for Plaintiffs

May 13, 1943.

[Endorsed]: Filed & Mailed copy F. L. A. Graham, Atty. for Deft. May 17, 1943 Edmund L. Smith, Clerk By Theodore Hocke, Deputy Clerk.

[41]

District Court of the United States
Southern District of California

Central Division

No. 1655-PH Civil

CRANFORD P. WALKER; and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as DEPTHOGRAPH COMPANY, a copartnership,

Plaintiffs and Cross-Appellants,

v.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Defendant and Cross-Appellee.

BOND ON APPEAL

Know All Men by These Presents that United States Fidelity and Guaranty Company, a corporation organized and existing under the laws of the State of Maryland, and duly licensed to transact business in the State of California, is held and firmly bound unto Halliburton Oil Well Cementing Company, a Delaware corporation, defendant and cross-appellee in the above entitled case, in the penal sum of Two Hundred Fifty and no/100ths ($250.00) Dollars, to be paid to said defendant and cross-appellee, its successors, assigns, or legal representatives, for which payment [42] well and truly to be made, the United States Fidelity and Guar-

anty Company binds itself, its successors and assigns firmly by these presents.

The Condition Of The Above Obligation Is Such, That Whereas, Cranford P. Walker, and Cranford P. Walker, D. A. Walker, Robert P. Miller and Milo C. Ketchum, doing business as Depthograph Company, the plaintiffs, are about to take an appeal to the United States Circuit Court of Appeals for the Ninth Circuit to reverse that portion of the judgment rendered and entered by the United States District Court for the Southern District of California, Central Division, in the above entitled case, on April 22, 1943, in favor of the defendant and cross-appellee, to-wit: Paragraph II of the Decree.

Now, Therefore, if the above named plaintiffs and cross-appellants shall prosecute said appeal to effect and answer all costs which may be adjudged against it if the appeal is dismissed, or the judgment affirmed, or such costs as the Appellate Court may award if the judgment is modified, then this obligation shall be void; otherwise to remain in full force and effect.

It Is Hereby Agreed by the Surety that in case of default or contumacy on the part of the Principal or Surety, the Court may, upon notice to them of not less than ten days, proceed summarily and render judgment against them, or either of them, in accordance with their obligation and award execution thereon.

Signed, sealed and dated this 17th day of May, 1943.

[Seal] UNITED STATES FIDELITY AND GUARANTY COMPANY

By C. D. BRICK
Attorney in Fact

Examined and recommended for approval as provided in Rule 13.

HAROLD W. MATTINGLY
Attorney for Plaintiffs and Cross-Appellants

State of California
County of Los Angeles—ss:

On this 17th day of May in the year one thousand nine hundred and forty-three, before me, Agnes L. Whyte a Notary Public in and for said County and State, residing therein, duly commissioned and sworn, personally appeared O. D. Brick, known to me to be the duly authorized Attorney-in-fact of the United States Fidelity and Guaranty Company, and the same person whose name is subscribed to the within instrument as the Attorney-in-fact of said Company and the said O. D. Brick duly acknowledged to me that he subscribed the name of the United States Fidelity and Guaranty Company thereto as Surety and his own name as Attorney-in-fact.

In Witness Whereof, I have hereunto set my hand and affixed my official seal the day and year in this certificate first above written.

[Seal] AGNES L. WHYTE

Notary Public in and for Los Angeles County, State of California

My Commission Expires Feb. 26, 1945.

[Endorsed]: Filed May 17, 1943. [43]

District Court of the United States
Southern District of California

Central Division

No. 1655-PH Civil

CRANFORD P. WALKER; and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as DEPTHOGRAPH COMPANY,

Plaintiffs,

v.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Defendant

STATEMENT OF POINTS ON WHICH PLAINTIFFS AND CROSS-APPELLANTS INTEND TO RELY ON APPEAL

Come Now the plaintiffs and cross-appellants in the above entitled cause and, in accordance with

Rule 75(d) of the Federal Rules of Civil Procedure, state that on the appeal the following points will be relied on:

1. The District Court erred in adjudging United States Letters Patent 2,209,944 invalid.

2. The District Court erred in adjudging United States Letters Patent No. 2,209,944 invalid as to each of the claims thereof as defining methods which do not involve invention and are unpatentable. [44]

3. The District Court erred in failing to find that the claims of United States Letters Patent No. 2,209,944 and each of them define patentable invention over the prior art.

4. The District Court erred in failing to find that the claims of United States Letters Patent No. 2,209,944 and each of them define a patentable method comprising a series of physical steps to produce information from which the results described may be computed.

5. The District Court erred in failing to find that the only prior art submitted by the defendant pertaining to the questions of anticipation and lack of invention were the same prior art which had been considered by the United States Patent Office during the prosecution of the applications resulting in United States Letters Patent No. 2,209,944 and that said Letters Patent and each of the claims thereof define patentable invention over any of such prior art.

6. The District Court erred in failing to find that the invention set forth and claimed in United

States Letters Patent No. 2,209,944 was a very meritorious invention, constituted a distinct advance in the art to which it relates, solved successfully for the first time a problem on which others had made many attempts but had never succeeded and that said patent is entitled to a liberal interpretation.

7. The District Court erred in finding that "United States Letters Patent No. 2,209,944 is a method patent and discloses and claims certain methods of determining the locations of obstructions in a well by introducing into the well a pressure wave and the recording of echoes from the various known obstructions or partial obstructions in the well, and calculating from information so acquired the location of the obstructions. The novelty of this structure consists only in the performance of [45] mental steps such as "counting", "observing", "computing" and "comparing", which do not involve invention."

8. The District Court erred in failing to find that none of the prior art before the Court disclosed or taught the methods defined in the claims of United States Letters Patent No. 2,209,944.

9. The District Court erred in failing to find that the novelty in the methods defined in the claims of United States Letters Patent No. 2,209,944 is more than the mere performance of mental steps and does involve invention.

10. The District Court erred in failing to find that the defendant has infringed each and every of

the claims of United States Letters Patent No. 2,209,944.

11. The District Court erred in not awarding costs of suit to plaintiffs.

HAROLD W. MATTINGLY
ROBERT W. FULWIDER
Attorneys for Plaintiffs and Cross-Appellants

Service of a copy of this Statement of Points on which Plaintiffs and Cross-Appellants Intend to Rely on Appeal is hereby acknowledged.

FRANK L. GRAHAM
EARL BABCOCK
Attorneys for Defendant and Cross-Appellee

[Endorsed]: Filed June 25, 1943. [46]

[Title of District Court and Cause.]

NARRATIVE STATEMENT OF TESTIMONY AND PROCEEDINGS IN DISTRICT COURT

The following is a statement of the testimony and proceedings in the District Court, part of which is in narrative and part in question and answer form.

Los Angeles, California
Tuesday, October 6, 1942
10:00 A. M.

Appearances:

Robert W. Fulwider, Esq., and
Harold W. Mattingly, Esq.
for plaintiffs.

Frank L. A. Graham, Esq.,
Earl Babcock, Esq., and
William R. Graham, Esq.,
for defendant.

During the opening statements at the trial, the following occurred:

Mr. Mattingly: At this time I would like to offer into evidence the three patents in issue, Nos. 2,156,519, Reissue 21,383, and 2,209,944, as the Plaintiffs' Exhibits 1, 2, and 3, respectively.

The Court: Any objection?

Mr. Graham: No.

The Court: In evidence.

[Printer's Note: Plaintiffs' Exhibits Nos. 1, 2, 3 are set out in full in the Book of Exhibits.]

Mr. Mattingly: And at this time I would like to offer into evidence the folder which was marked Exhibit 1, attached to the bill of particulars, as Plaintiffs' Exhibit 6. [48]

Mr. Frank L. A. Graham: Will you give that a name, please? "An echo writes the fluid level of your well."

Mr. Mattingly: Also attached to the Bill of Particulars was a single sheet advertisement or apparently a reprint of an advertisement put out by the Halliburton Oil Well Cementing Company, and marked Exhibit 2 in connection with the Bill of Particulars; and at this time I would like to offer that into evidence.

The Court: It will be No. 7. That will be the "Echo Meter" folder. Do you offer both sides of this Exhibit?

Mr. Mattingly: Yes, Your Honor.

The Court: All right.

[Printer's Note: Plaintiffs' Exhibits Nos. 6 and 7 are set out in full in the Book of Exhibits.]

Mr. Mattingly: Also attached to the Bill of Particulars were five sheets of records, four of those sheets bearing as a heading "Echo Meter Field Data Record"—and the largest of the sheets, the fifth sheet, bearing the title "Sub-Surface Pressure Test Data—Potential Determination for Pumping Wells." Each of these sheets also bears notation "Company Surf Associates Well State No. 1—Field Huntington Beach." Those sheets were attached to the bill of particulars.

The Court: All right. The four sheets will be numbered 8, 8A, B, C and D. And the long sheet, the "Central Committee" sheet, the long one which is: "Central Committee of Calif. Oil Producers, Office of Oil Umpire, 1160 Subway Terminal," shall we call that the "Central Committee" exhibit?

Call the other the "Halliburton Co. Echo-Meter Data" sheets 8A, B, C, D? [49]

The Clerk: That will be Plaintiffs' Exhibits "8A, B, C and D."

[Printer's Note: Plaintiffs' Exhibits Nos. 8A, 8B, 8C and 8D are set out in full in the Book of Exhibits.]

The Court: That is right; and No. 9 will be the "Central Committee Echo-Meter Field Data" from the same well, "State No. 1—Huntington Beach."

[Printer's Note: Plaintiffs' Exhibit No. 9 is set out in full in the Book of Exhibits.]

Mr. Mattingly: In this case, your Honor, we filed interrogatories on behalf of the plaintiffs and at this time I would like to offer into evidence interrogatories filed by plaintiffs and answers filed by the defendant thereto. May we have the Interrogatories admitted in evidence as Exhibit No. 10, and the Answers to the Interrogatories as Plaintiffs' Exhibit 11? And I offer the Supplemental Answer in evidence as Plaintiffs' Exhibit No. 12.

[Printer's Note: Plaintiffs' Exhibits Nos. 10, 11, and 12 are set out in the Book of Exhibits.]

The Court: The drawing marked Exhibit No. 4 attached to Plaintiffs' Interrogatories,—the Interrogatory number is 10,—call that 10A then.

[Printer's Note: Plaintiffs' Exhibit No. 10-A is set out in full in the Book of Exhibits.]

Mr. Mattingly: I offer in evidence as Plaintiffs' Exhibit 11A, Defendant's Exhibit No. 16 accompanying Defendant's Answers to Interrogatories; as Plaintiffs' Exhibit 11B, Defendant's Exhibit No. 17 accompanying Defendant's Answers to Interrogatories; as Plaintiffs' Exhibit 11C, Defendant's Exhibit No. 18 accompanying the Answers to Interrogatories. That Exhibit is an instruction book bound in brown. As Plaintiffs' Exhibit No. 12, the Supplemental Answer to Plaintiffs' Interrogatories; as Plaintiffs' Exhibit 12A, Defendant's Exhibit No. 19 attached to Supplemental Answers to Interrogatories; Plaintiffs' Exhibit No. 12-B, Defendant's Exhibit No. 20 attached to the supplemental answer to the [50] interrogatories; as Plaintiffs' Exhibit No. 12-C, Defendant's Exhibit No. 21 attached to the supplemental answer to the interrogatories; as Plaintiffs' Exhibit No. 12-D, Defendant's Exhibit No. 22 attached to the supplemental answer to the interrogatories; as Plaintiffs' Exhibit No. 12-E, Defendant's Exhibit No. 23 attached to the supplemental answer to the interrogatories.

[Printer's Note: Plaintiffs' Exhibits Nos. 11-A, 11-B, 11-C, 12-A, 12-B, 12-C, 12-D, and 12-E are set out in the Book of Exhibits.]

In addition to these pleadings that I have mentioned so far, the plaintiff and defendant have agreed on a stipulation as to certain facts with

regard to this case, and I offer in evidence the stipulation just referred to as Plaintiffs' Exhibit No. 13.

[Printer's Note: Plaintiffs Exhibit No. 13 is set out in full in the Book of Exhibits.]

That new drawing, with the corrections, is the drawing which is attached to our pre-trial brief, and I offer in evidence an enlargement of that drawing which was attached to the pre-trial brief, as Plaintiffs' Exhibit No. 14.

Mr. F. L. A. Graham: Your Honor, we would object to that being offered in evidence. If it is to be used as a true and correct showing of our device we would like some evidence on that. It is a drawing plaintiffs have made up apparently from the interrogatories. I would say, in general, it shows the general features of the device, but I don't know whether it corresponds or not.

The Court: I don't think it is evidence. It is argument. [51]

Mr. Mattingly: The reason I would like to offer that in evidence, your Honor, and I think it is evidence, is that the supplemental answer to interrogatory No. 14 refers to and enumerates various parts, identifies various parts of the defendant's apparatus, and then describes it by reference to some drawing.

Mr. F. L. A. Graham: If the court please, this drawing, of which that is a modification or revised edition, was made by the plaintiffs. It is not evidence, but just a drawing that counsel has had

made, and he has offered it in evidence without any proof of these things which are shown in the drawing. You can use that in argument.

The Court: I think that is correct. That is argument. It is here, but it is not evidence unless you lay a foundation and identify it.

Mr. Mattingly: Then may we have that enlarged drawing marked for identification?

The Court: All right.

The Clerk: Plaintiffs' 14 for identification.

The Court: That is a drawing of what?

Mr. Mattingly: A diagrammatic drawing of the defendant's apparatus.

The Court: Is it the defendant's apparatus?

Mr. Mattingly: Yes.

The Court: A drawing of the defendant's apparatus?

Mr. Mattingly: We might refer to that as a drawing illustrating defendant's answer and supplemental answer to interro- [52] gatory No. 14.

The Court: It is offered for identification as a drawing of defendant's apparatus, is that correct?

Mr. Mattingly: Yes.

Mr. F. L. A. Graham: Put it this way: Plaintiffs' illustrative drawing of defendant's apparatus.

The Court: I have it in my notes that it is plaintiffs' idea of defendant's apparatus.

Mr. Frank L. A. Graham: May I interrupt, your Honor? May I ask counsel if the filter, for instance, such as used by defendant is not used, why, then you do not claim infringement?

Mr. Mattingly: That is correct in so far as patent -519 is concerned, unless the defendant uses some other means for accenting the tubing collar echoes.

Mr. Frank L. A. Graham: Counsel is familiar with our apparatus and he has described it as having a filter in it. Now, I ask counsel if he will take the position at this time, if we do not use the filter do we infringe patent -519? I think that is a fair question.

Mr. Mattingly: If in your electrical system you do not use any other device which would act like or perform the same function of selecting out these particular echoes, I believe we would be willing to stipulate that there would be no infringement. I can make that, perhaps, clearer this way: That as long as the defendant does not in its system use any means especially adapted to [53] accenting the tubing collar echoes there would be no infringement of patent '519.

The Court: None at all? '519 is the mechanical apparatus.

Mr. Mattingly: That is correct.

The Court: If he does not use the filter or tuning device, that is, a device calculated to catch these tuning joints with regularity, then you claim no infringement of '519?

Mr. Mattingly: That is right.

The Court: You claim then, only infringement of the method?

Mr. Mattingly: That is right, because in the

method patent '944 we are not limited in our claims there to any tuning.

The Court: Let me go back again a minute now. That being the case, it is your position that the firing of the shell into the well, the electrical microphone and the tape, the recording apparatus, is not an infringement of '519?

Mr. Mattingly: That is correct. There must be that additional element, something which accents the tubing collar echoes associated with those other two devices. The reason I hesitate to stipulate——

The Court: You do think that firing with that shell, the use of the electrical microphone and the gas cooling its elements and recording the vibrations or creating the oscillation does violate—what is the method patent?

Mr. Mattingly: '944.

The Court: —'944?

Mr. Mattingly: That is right. [54]

The Court: I don't know. I can't see it. No doubt it is clear to everybody else in the court room, but it is not clear to me. You contend that the use of the electric filtering system is a violation of your rights to record with regularity the echoes produced from the joints, even though your patent is on a mechanical tuning sytem, and you do not contend that the projection of sound into the well by shot and the recording of it on an electrical microphone is a violation of your rights under the mechanical patent of your sound vibrating mechanically a diaphragm and recording it, instead of an electrical microphone and the introduction of the gas?

Mr. Mattingly: That is correct. Perhaps I can clear that for your Honor this way: That our mechanical patent represents one invention which was presented to the Patent Office and on which the patent was granted; and that invention is expressed in terms of the three elements in combination with each other.

The Court: Yes; three instrumentalities.

Mr. Mattingly: That is right.

The Court: One that introduces sound——

Mr. Mattingly: If the defendant omits one of those instrumentalities, then he does not infringe a claim which has been granted on a three-element combination.

The Court: Oh. It is essential to your mechanical patent '519, for anybody to infringe it, that he use all three of them?

Mr. Mattingly: That is correct. [55]

The Court: The reason, then, that he does not violate '519 by the introduction of the shell and the use of the diaphragm is because he does not use—assuming that he does not—he does not use the tuning device?

Mr. Mattingly: That is correct.

The Court: But if he brought in one of the others and used the tuning device he still would not be violating it, is that right?

Mr. Mattingly: He still would not be violating it, because in order to infringe that patent he must use all three elements. Now, if he does not produce sound and does not have any means for producing a sound in the well, then he would not in-

fringe the claim. If he does not use any means for recording or registering or otherwise recognizing that set of echoes when they come back, he would not infringe; and likewise, if he does not use the filter.

On behalf of the Defendant the following exhibits were offered and received in evidence:

Exhibit A—Certified copy of file wrapper and contents of abandoned application of Cranford P. Walker, Serial No. 270,865 filed Apr. 29, 1939.

Exhibit B—Certified copy of file wrapper and contents of application filed [56] Sept. 25, 1939, which resulted in Patent No. 2,209,944 in suit.

[Printer's Note: Defendant's Exhibits A and B are set out in full in the Book of Exhibits.]

MALCOLM WELLS MORRIS

a witness called by Plaintiffs, testified as follows:

Direct Examination

My business address is Standard Oil Company, Standard Oil Building, Los Angeles. I have been employed by the Standard Oil Company since 1929 as a production engineer. I was located in Taft, Kern County oil fields from 1929 to 1939; 1939 to the present date, Los Angeles, dealing with the Los Angeles Basin [57] and Coastal oil fields. My production engineering work is concerned with the engineering features of efficiently producing oil from the ground, working with the production super-

(Testimony of Malcolm Wells Morris.)

intendents, production foremen of various fields. In the course of my duties I kept abreast of the times as to any developments in my department by reading technical publications, attending meetings of technical oil societies, discussion with other engineers and oil men. I have been an officer in the American Petroleum Institute continuously since 1930, that is, from 1930 to 1939, in the San Joaquin Valley Chapter of the American Petroleum Institute; 1939-1940 in the Long Beach Chapter as member of the drilling and production practice committee. It is a national committee of the American Petroleum Institute—in 1938, 1939, 1941 and this year. January 8th to August 1st of this year I served on the engineering sub-committee, the District Five Production Committee, making a survey of the oil reservoirs of the State, the way they should be produced and how much oil we could expect to obtain.

I am familiar with the measuring of sub-surface pressures and the acquiring of other data which you might call sub-surface data in oil wells. I started working on that when I first came to Standard Oil Company in 1929. I was co-author of a paper entitled "Use of Depth Pressure Data in Determination of Well Potentials in California" which was presented at the mid-year meeting of the American Petroleum Institute at Tulsa in May, 1941, and was published in the 1941 volume of Drilling and Production Practice, and another publication of the American Petroleum [58] Institute. The

(Testimony of Malcolm Wells Morris.)

nature of my early work in this field, that is, the sub-surface pressure measurement, was in helping the development of the depth pressure recorder, which the Standard Oil Company of California was able to develop and work out successfully. A depth pressure recorder which is used by the Standard Oil Company of California is an instrument which is used to measure pressures in an oil well. It is lowered into the oil well on a steel line, similar to piano wire. Shots are made at intervals as desired, and pressure recordings obtained. The instrument is 1¼ inches in diameter by 5 feet long. The pressure is recorded by a stylus on a chart drum which is turned by a clock. The oil pressure acts on the piston which travels through a packing gland, in order to keep oil out of the instrument. This instrument is attached to a rod which works against a spring in tension. The characteristics of the spring are determined so that one inch of travel represents so much pressure.

Prior to 1936 it was recognized as being necessary to secure sub-surface pressure and other sub-surface data. In 1929 our company was actively engaged in attempting to develop an instrument which would permit us to measure pressures in an oil well.

The depth pressure recorder can be used to measure pressures in a pumping well. We employed it for the measurement of the pressures in a pumping well by attaching the instrument below the pump. In that case we used a clock, which oper-

(Testimony of Malcolm Wells Morris.)

ates [59] from 5 to 8 days, and could obtain a record of pressure changes in the well during that period. In order to install it you have to take the pump out. Our instrument is sufficiently small so we can ordinarily install it without having to remove the tubing in a pumping well.

In explanation as to why a knowledge of sub-surface pressure is desirable, I will say that an oil man is handicapped by the fact that he never sees his work bench, and sub-surface pressure information gives knowledge as to the characteristics of the oil zone that you are attempting to exploit, and of the particular well which opens the zone. It gives information of importance, such as static pressure, which represents the pressure in the zone when you are not removing a fluid; and the producing pressure, which is a pressure which is determined at a desired rate of production.

The fluid level measurement is an old art in the oil industry under static conditions. It represents the first approach or attempt to determine pressures in the reservoir when fluids are not being withdrawn. In the Standard Oil Company of California it is standard procedure, whenever pumping equipment is removed from the well, to run a bailer in on the sand line, and determine the position of the fluid in the hole. We were not able to determine the position of the fluid in the hole with the well pumping, and we had no equipment that we could run down between the tubing and the casing of the well. [60] Also, it was customary

(Testimony of Malcolm Wells Morris.)

practice to use a catcher set on the tubing, which would be an obstacle, which would prevent the passage of any instrument which you might try to lower in the well under producing conditions.

I have heard of some attempts being made to measure fluid between the tubing and the casing by means of floats or equipment run in on the line.

By Mr. Fulwider:

Q. Is it desirable, or was it recognized prior to 1936, as being desirable to know the density or gradient of the fluid in the well?

A. With the development of a satisfactory pressure recorder we were able to determine the density or gradient under producing or shut-in static conditions in flowing wells, and that information proved to be of great benefit to us in our operations. With our depth pressure recorder installed below the pump in pumping wells we were able to measure pressure below the pump with the well producing or shut in. However, we were not able to determine the gradient. I personally felt that a knowledge of gradients under pumping conditions would be quite illuminating and helpful.

The Court: What do you mean by "gradient" —pressure?

A. Gradient is the pressure in terms of depth pounds per hundred feet expressed by a column of oil, water or gas. [61]

By Mr. Fulwider:

Q. That is really synonymous with density?

(Testimony of Malcolm Wells Morris.)

A. That is correct.

Q. How about well potentials or capacities?

A. We calculated, starting in 1931, well capacities of flowing wells. It was a regular operation. We, to a lesser degree, calculated the same type of information in our pumping wells by installing a recorder below the pump.

The Court: Did you keep the recorder there all the time?

A. No, sir, we took the measurement and removed it. Our first instrument had to be installed on the tubing; we had to remove the rods, pump and tubing.

Prior to 1936, to my knowledge there was not any apparatus available to the oil industry for determining producing fluid levels or density in pumping wells. The pressure recorder yielded measurement on the pressure, but gave no information as to density of pumping wells or levels under pumping conditions. Under static conditions we could obtain density and fluid level. And, so far I know, there was no other apparatus on the market or method by which you could obtain these determinations.

I am acquainted with Mr. Cranford P. Walker, and am also acquainted with his depthograph methods and equipment. I first became acquainted with Mr. Walker on May 1st, 1936. I received a call from the production engineer at Kettleman, who advised [62] that Mr. Walker had made a demonstration

(Testimony of Malcolm Wells Morris.)

on a Standard Oil Company well in the Coalinga field that morning and was driving down into Taft that afternoon and would make a free demonstration for us if we desired. Mr. Walker came in the office that afternoon and introduced himself. He explained briefly the type of information that he could develop and the principles of his method. I had arranged for a demonstration at well No. 218, Section 33-D, Lake View area. That is situated a few miles from Taft.

By Mr. Fulwider:

Q. Did Mr. Walker put on that demonstration that you had arranged for?

A. Yes. He hooked up his apparatus to the casing head on the well and made a graph of the showing of fluid level, the echo from the fluid level in the well, with the well pumping. I witnessed the tests, as well as several other members of the production staff. In the method he then used, he hooked up his recording instrument, introduced a charge of high-pressure gas into the casing head of the well, recorded the time that was required from the time the gas was released into the casing head of the well until it went to the fluid level and was returned to the casing head.

We didn't attempt to determine fluid level on this demonstration. It was getting late in the evening and the fluid level was above the tubing catcher in the well. There was no way of determining the depth of the fluid level. [63]

(Testimony of Malcolm Wells Morris.)

We simply had the picture and record of the number of seconds it took for this pressure wave to travel from the casing head to the fluid and return. He explained that he had an instrument, a calibration tube, which he could hook up and could estimate the rate of travel of the pressure wave in this particular well. As I said, it was getting late and we were not interested at the time, sufficiently interested at the moment to wait around while he did this additional work. This was simply a qualitative demonstration that showed that he could measure the time for this echo to go from the well head to the fluid and return. It was one echo. We felt the fluid must be above the catcher, because if it had been below the catcher we would have expected to have gotten an echo from the catcher and from the fluid.

Later work verified that, but it was not verified on that particular well. This is simply an account of the first time I saw the instrument and the first time it was used in my presence. My reaction was that I was interested in the possibilities of the instrument, but I was skeptical, or I wanted to be shown that it was of sufficient accuracy to make it usable for helping us in solving our problems. Prior to that, I had heard talk among the industry that such an instrument was available, but I had no first hand knowledge as to its accuracy. [64]

I requested Mr. Walker to return at his convenience for a further discussion regarding the equipment. He came in the office the following day, that

(Testimony of Malcolm Wells Morris.)

is, May 2nd, 1936, and explained the work that he had done and what he thought he could accomplish, in more detail than we had had time to review it the preceding afternoon. He explained that there were two methods by which he could evaluate the position of fluid level, namely through the use of a calibration tube. This was a measured section of pipe which was set up at the surface near the well, gas from the well was introduced from the tube and velocity of travel of pressure wave in the well gas was determined under surface conditions. From that an estimate was made as to what the velocity of travel of the pressure wave would be in the well. I was quite skeptical as to the absolute accuracy of that method.

The second method was to use the velocity indicated in the well by reflection from a known obstacle, which might be a tubing catcher or possibly a top of a smaller size of casing, a liner top, where the depth to that obstacle was known. Using the velocity calculated from that depth and the time for the echo to go from the surface to the obstacle and return, and the time from the surface to the level and return, you could calculate the position of the fluid level. I was dubious as to [65] whether the velocity of the wave in the well would be sufficiently constant that you could secure accurate results by extrapolating deeper into the earth from the velocity indicated in the upper portion of the hole.

(Testimony of Malcolm Wells Morris.)

Mr. Walker offered to make free tests if we would supply the wells, would cooperate by supplying the wells. This offer was approved by the management and we made arrangements for tests that we thought would prove or disprove what the instrument was good for. As wells were pulled for repairs to the pump, we installed obstacles, reflection points on the outside of the tubing at variable intervals above the tubing catcher. The position of these reflectors was measured by the company and recorded. From two to four additional obstruction points or reflectors were installed on the tubing in the seven wells that were selected for the tests. The test work was started on May 14, 1936, and extended over a period of several weeks. The position of the top reflector, the depth to the top reflector, was supplied to Mr. Walker, and he was requested to determine the position of the other reflection points in the well and advise us as to the depth, and to give us copies of the graphs so that we could check his determinations. Repeated tests were conducted at the seven wells under the different varying conditions of surface pressure and production. The data were [66] analyzed for errors which could be attributed to unfaithful recording, interpretation of charts—that is, the personal element, whether one man would measure the chart the same as another man—and third, as to whether the velocity of the wave changed sufficiently in the well so as to introduce errors through extrapolating from high reflection points to lower ones.

(Testimony of Malcolm Wells Morris.)

Q. What method did he use in computing the unknown locations of the reflectors in those tests?

A. The velocity of the pressure wave to the top reflection point was calculated from the depth measurement to the point we had supplied Mr. Walker and the time which was recorded on the graph. We checked all of his determinations. Then he took the time to the lower reflection points and, with the velocity determined from the upper known point, calculated the depth of the lower points.

By the Court: Was he accurate?

A. We analyzed 127 runs and came to the conclusion that the average deviation in those tests was six feet, which was sufficiently accurate for our purposes. For example, he calculated the position of reflector point 3000 feet, and on the average he was within six feet of that depth.

By Mr. Fulwider:

Q. His method, then, in general constituted comparing of the time space on the chart of the known to the time space on the chart of the unknown?

A. That is correct. For example, we possibly installed [67] the first reflectors at 2000 feet. The depths were random depths. We deliberately mixed them up so that there was no sequence there that he could use in getting the answer. But the known reflection point was approximately 2000 feet. We might have installed the next reflection point at possibly close to 2400 feet, another one at possibly 2600 feet, and another one at 2750, on the same well. And Mr. Walker was given the depth of the top

(Testimony of Malcolm Wells Morris.)

point. He was requested to supply us with information as to what he calculated the positions were of these other reflection points; and, for example, if this lowest reflector were at 2750 his average error was six feet.

We took the charts which he submitted and further analyzed them, and using the top reflector and recalculating the position of the others, using the next to the top reflector and calculating the top and the lower reflectors, and took the third reflector and calculated those, and took the fourth and calculated the others. We could calculate up or down, either way. He was unable to do that, as we never supplied him the depth of the other reflectors. The shorter the extrapolation the greater accuracy. Extrapolation there means distance from the known point to the unknown, in a straight line.

Q. Did he subsequently do any commercial tests for you?

A. We requested him to measure the fluid level in four [68] wells in Mountain View. The work was done between August 7th and August 11th, 1936. This was paid work.

Mr. Frank L. A. Graham: Just a minute. If your Honor please, we object to any testimony about these, unless we know that the apparatus used was the apparatus of the patent. We don't know what that was.

The Court: Well, I don't know how we are going to find out until we get a chance to have the witness tell us.

(Testimony of Malcolm Wells Morris.)

By Mr. Fulwider:

Q. What apparatus and method did Walker use on those tests?

A. The method that was used on the test was to close in the casing head of the wells and the pressure, surface pressure, was permitted to build up to the maximum at which time Mr. Walker connected up his equipment and introduced a pressure wave. Do you want to go all through that again?

The Court: Well, he wants to know what he did, if he used his equipment. Did he have all his gadgets there?

A. Well——

Q. You don't know whether he had all of them. All right.

A. I am not familiar with the patent so far. I have never gone into that particular.

Q. You said he connected his equipment.

A. Well, he took and measured that fluid level for us by [69] this equipment. He introduced the pressure wave—and we could go all through that.

Q. Go ahead and tell us what he did.

By Mr. Fulwider:

Go ahead.

A. Introduced the pressure wave into the well, measured the time required for the pressure wave to go to the fluid level and return. The depth to the fluid level was calculated from a reflection point which was above the fluid, which we knew the depth to the reflection point.

(Testimony of Malcolm Wells Morris.)

By the Court: Had you installed a special reflector?

A. Yes, sir; we had a reflector installed there. It was a tubing catcher in this case. The fluid level was above the pump in these wells, and we estimated the pressure at the pump by assuming that the liquid fluid in the well was of tank oil density, corrected for the temperatures at the bottom of the well.

Q. In these tests at Mountain View, or prior tests that you have mentioned, what was the nature of the curve of the graph between the shot point at the top and the first major reflection either from the known or unknown.

A. It was an erratic line with small jiggles, and in general simulated a sine curve. That is, it had a shape such as that.

Q. Was there sufficient regularity to it, or did it have any characteristics which would enable you to distinguish what [70] those peaks meant?

A. We had no knowledge of what those peaks meant.

Q. In this early test, the only portions of the graph that you used were the major reflections which showed up clearly?

A. Fluid level reflections, or any reflection from a point above any obstacle.

Q. Such as tubing catchers, or reflectors that you put in?

A. That's right. To calculate the pressure at the pump, we closed the casing heads up and al-

(Testimony of Malcolm Wells Morris.)

lowed pressures to build up to maximum before taking a measurement of the fluid level, in order to get the gas column as close to the pump as we could. We knew how to determine the pressure increment in the gas column, but were uncertain as to what the gradient would be between the top of the fluid level and the pump. We did not have any certain knowledge at that time, so, in order to minimize the effect of that uncertainty, we forced the fluid as low as we could with the means that were available at the well.

We were interested in using the Depthograph method at these wells to determine two things: First, whether or not we were obtaining the maximum amount of oil from the well. These wells were located in a highly competitive producing area, and we wished to get every barrel possible out of them. In case the wells were not being pumped off; in case we were not obtaining the maximum amount of oil that the wells were capable of [71] yielding, we wished to get an idea of how much more oil might be available, from measurements made through the area with our depth pressure recorder.

When the wells were on flowing or gas lifting we had what we felt were reasonably good estimates of what the static pressures were in the oil sand when we were not producing oil. It as recognized procedure to determine the pressure in the oil sand of those producing, and from the static pressure and producing pressure to calculate the

(Testimony of Malcolm Wells Morris.)

productivity index; that is, the number of barrels per day of oil obtained for every pound that produced pressure below the static.

To determine the fluid level at these wells, it can be likened to a qualitative measurement, possibly on the order of where you put your hand on your child's brow. You find it is hot; you have a qualitative idea that he is possibly sick. By using a thermometer you obtain a quantitative determination of what the fever is. If the wells were not pumping off we wished to get as accurate an idea as possible of what the producing pressures were in the wells.

By the Court: The producing pressure—bottom hole pressure?

A. Bottom hole pressure, yes; the pressure against the oil sand. We could approach that by using the surface pressure, which we measured with a test gauge, by computing the increase in weight between the surface and the fluid level, due to the gas column weight; but it was necessary to estimate the amount [72] of pressure represented by the length of fluid between the pump and the fluid level.

By the Court: You assumed the fluid level?

A. We assumed that the fluid level was dense oil, at that time, but I was uncertain about that. That was purely an assumption, and in order to minimize the error, if that assumption were erroneous, I stipulated that we could drive the fluid as close to the pump as we could and thereby minimize

(Testimony of Malcolm Wells Morris.)

the estimate that we had to make for the pressure increment between the fluid and the pump.

By Mr. Fulwider:

Q. That is, the gravity of the oil in the tank which you could measure was only an approximation of the gravity of the oil down at the pump, is that correct? You were assuming that they were the same for the purpose of that calculation?

A. At that time I was of the opinion that fluid near the pump was oil.

By the Court: I think I understand. In other words, you could measure the density of gas, but you could not measure the density of the fluid, because you did not know what the fluid was?

A. That is correct.

By the Court: You were assuming if you knew it was all oil you could measure the density? [73]

A. That is correct.

By the Court: Therefore you wanted to eliminate the unknown quantity, to-wit, the fluid?

A. From the considerable amount of work that we had done with the depth pressure recorder in flowing wells we had a good knowledge as to gradients and flow tube under producing conditions, and that had raised uncertainty in my mind as to what the gradients of the fluid might be between the tubing and the casing in a pumping well under producing conditions. While this assumption that I made in calculating the pressure of the pump was logical I was uncertain of it, and I tried to mini-

(Testimony of Malcolm Wells Morris.)

mize the error that would be induced if I was wrong, by driving the fluid as close to the pump as possible.

By the Court: The purpose of these tests at the Mountain View field was to ascertain the bottom hole pressure? Was that the ultimate thing you wanted to find out?

A. There were two purposes: to determine whether or not we were getting all the oil from the wells that the wells were capable of yielding. This was a highly competitive producing area, and we wanted to get the oil before our neighbors got it. Secondly, if the wells were not pumping off; if we were not getting all the oil available, to get an estimate of how much more oil we might be able to obtain.

By the Court: By obtaining the bottom hole pressure? [74]

A. Yes. We know the static pressure. By ascertaining the producing bottom hole pressure we could calculate how many more barrels of oil per day we could obtain from the well. That would permit us to plan on what change of equipment we might have to make in order to get the additional oil, and to work out the economics of the change. We could not afford to spend a thousand dollars to get only five barrels a day more oil. Both of those results were calculated from the fluid level.

By the Court: The bottom hole pressure is ascertained from the fluid level?

(Testimony of Malcolm Wells Morris.)

A. We were estimating the bottom hole pressure from a single fiuid level measurement.

By Mr. Fulwider:

Q. You have described the method that you used in the Mountain View test. I wonder if you will, in a few words, describe the apparatus that Mr. Walker used to make this determination in the Mountain View field, in response to Mr. Graham's query.

By Mr. Graham: I would prefer that the witness testify as to what he saw there. This is a very interesting point, and I want to know.

By Mr. Fulwider:

Q. Just describe as best you can the type of apparatus Walker employed.

By the Court: Have you seen his apparatus since?

A. My goodness, yes. It all looks the same though; it is always inside of the box. [75]

By Mr. Graham: May I ask what these notes are he is referring to now?

The Witness: This is the report which was prepared under my supervision, under date of May 10th, 1937, entitled: "Depthograph Equipment and Its Operation."

By Mr. Graham: Your Honor, that report is dated May, 1937; the Depthograph and its operation. What does that describe?

A. It describes something that was seen and reported on after these tests in 1936.

Q. What was that description taken from, do you know?

(Testimony of Malcolm Wells Morris.)

A. It was taken from our engineer, who was following these tests. It is his description of the apparatus.

By Mr. Graham: Then you don't know of your own knowledge, the description that your engineer has made, whether it applies to something in 1936 or 1937?

A. This description, to my knowledge, is the same as the apparatus that was used all through that period.

By Mr. Graham: There was no change in the apparatus?

A. I am interested in the apparatus as a service. We tested their method; their equipment; we fould it could do certain things which we considered would be satisfactory, and we commissioned them to do certain work for us. We watched the work to be sure they were using the equipment or the method which we had checked. We did not ask them to take their apparatus apart each time. [76]

By the Court: What you are saying is you don't know whether there was any change or improvement?

A. There was no change to my knowledge in the apparatus being used for this single shot work.

By the Court: Tell us what the equipment looked like in 1936.

By Mr. Graham: I want to know what he saw in 1936.

By Mr. Fulwider: We have an apparatus here in court as to what is being used now. We can

(Testimony of Malcolm Wells Morris.)

mark it for identification for the purpose of discussion, and let him point out any differences, and describe them.

By Mr. Graham: This man is an engineer. He went there particularly, and had these tests made. If he was not interested enough in the apparatus used to see the different parts of the apparatus, and how it worked, all this testimony is of no account. I want to know what this witness saw at that time.

By Mr. Fulwider: I was trying to save time.

By Mr. Graham: I don't want him to look at the apparatus which is made now, and testify from that.

By Mr. Fulwider: Describe then, in your won words, without the benefit of drawings or physical exhibits, what the apparatus was that you saw used in the Mountain View tests.

A. The apparatus that I saw used consisted of a supply of high-pressure gas, which was bottled. It was in a sealed [77] bottle of the type that is used, containing oxygen and acetylene, for welding purposes. That was connected into a piping arrangement from the casing head of the well to the recording equipment. Between the pressure connection and the recording equipment there was a quick closing valve of a large diameter, the opening in it being approximately the diameter of the piping. Two-inch piping was what was customarily employed. Around the quick closing valve was a by-pass of small piping, approximately a quarter of an inch, with a needle valve. Beyond this piping was the recording device, which consisted of a ground

(Testimony of Malcolm Wells Morris.)

glass in which you could get a reflection of light, which gave the indication of the return of the pressure wave from the obstacle; and inside of the equipment was a recording device for taking a photograph of those slight impulses.

By the Court: This was not a stylus?

A. No. The tuning fork arrangement was used to control the timing of the apparatus. That was used after the first preliminary testing work. The original timing was not satisfactory. It depended on the cycles of the Edison Company's light circuit, and it was not of sufficient accuracy, and that was changed early in May, and our subsequent work was then done with the tuning fork controlled [78] timing. The echo impinged on the diaphragm, which operated the mirror, so as to throw a light on the ground glass so that you could see it. This threw the light on a sensitive tape to photograph the path of the light. The by-pass around the large valve was for the purpose of keeping the impact of the pressure wave off of the diaphragm when it was first introduced into the well head.

By Mr. Fulwider:

Q. What equipment you have described, was that used by Mr. Walker on all of these tests about which you have testified?

A. That is correct.

Q. The method of operating that equipment, will you describe that just briefly?

A. The technique was to introduce a charge of

(Testimony of Malcolm Wells Morris.)

gas from the pressure bottle into the piping around the casing head with the by-pass valve open. Immediately after the pressure charge was introduced into the well, the main valve was opened. The film recorded the travel of the wave down the oil well to the fluid level and return, after which the apparatus was shut off. In the early test we were interested in the velocity changes in the wells, and we took as many as two or three complete recordings of the travel waves from the casing head to the fluid and return; to see if there were any indications of changes of velocity.

Q. Do you recall any tests made the latter part of [79] December, 1936, which were of particular significance, or otherwise?

A. The company requested the testing of three wells at Mountain View, and a well at Poso Creek. The test at Abadie No. 1, at Mountain View, was the first test to my knowledge where a measurement was taken of fluid gradients.

By the Court: Different people use the phrase "to my knowledge" in a different sense. Some of them use it in a sense that they know absolutely, and others use it in a sense of so far as their knowledge is concerned. How do you use it? You say that was the first test to your knowledge. Do you mean you know that was the first time?

A. I mean it in the sense that that was the first test I was aware of or familiar with, where we obtained a measurement and a determination of fluid gradients in the annulus between the tubing and

(Testimony of Malcolm Wells Morris.)

the casing, with the well pumping. That was Abadie No. 1, at Mountain View, starting December 29th, 1936, and was concluded December 31st, 1936.

In this test at Abadie No. 1, the pressure was built up from about 40 pounds at the surface to about 340 pounds. The well produced a small amount of gas, and the pressure built up very slowly, requiring about 48 hours to build up that amount. The operator of the Depthograph equipment observed the fluid level as the pressure built up; and Mr. Walker submitted data to us in a graph form of a plot of depth versus gas pressure—depth against gas pressure. Depth is the ordinate and the [80] gas pressure is the abscissa. The data plotted was substantially a straight line with a fluid density of 18.6 pounds per hundred feet. The solid oil density was approximately twice that. The fluid was moved from a position about 16 feet above the pump down to the pump inlet. That straight line indicated that the fluid density was constant, on the original position of the fluid level, with our operating casing pressure of about 40 pounds, down to pump.

Q. Was that a new idea to you at that time?

A. It came as very much of a shock to me.

Q. Had Mr. Walker ever told you anything about that, or propounded that relationship as a theory to you prior to that time?

A. I don't recall that he had. If he had produced any convincing evidence that this relationship existed I would not have been surprised at the

(Testimony of Malcolm Wells Morris.)

determination in our well. This measurement completely changed my conception regarding conditions in pumping wells. My conception prior to that was that there was a light froth near the top of the operating fluid level in a pumping well, and with depth down near the oil sand the oil was practically gas free; substantially solid oil. It was on that basis that I had previously estimated pressures, on our entire determinations, in August and subsequent months, as to what the operating pressures were at the pump. [81]

By Mr. Fulwider:

Q. Was there any one in your organization who had shared your previous view as to the density of the fluid?

By the Court: Was that the general conception in the industry?

A. I am not qualified to speak for the industry. It was, in our organization, your Honor. Those determinations completely revised our conception regarding conditions in these pumping wells.

By the Court: You were not familiar with the general conception that men had, who occupied the same position in other oil companies?

A. I have discussed the problem with them.

By the Court: Concerning the characteristics of that fluid was their conception of it the same, or approximately the same, as yours?

A. It was.

(Testimony of Malcolm Wells Morris.)

By Mr. Fulwider:

Q. You mentioned that Mr. Walker ran some Depthograph tests at Poso Creek, with the same equipment that you have described; can you tell me the nature of those tests, and anything of interest in connection with them?

A. That test was of interest, because we obtained only a single reflection in this well, which indicated that the fluid level was above the tubing catcher and the measured reflection point which we had placed on the tubing in the well [82] above the tubing catcher. The chart that was obtained had a series of echoes, which Mr. Walker said represented reflection from the tubing collars, and the tubing collars were counted, and from the measurements of tubing string we calculated the position of the fluid level.

By the Court: Was that verified as to each one from the tubing collars?

A. We verified them subsequently. At the moment we were interested in the fact that the fluid level was not below our measured reflection points. We found it was up in the hole. We proceeded to make a change in the apparatus to get more oil from the well. Our interest in this was that we always were working to get more oil. We were not worried so much from their side of it.

By Mr. Fulwider:

Q. You say Mr. Walker counted the echoes which represented tubing collars?

(Testimony of Malcolm Wells Morris.)

A. He said that the echoes did represent the tubing collars.

By Mr. F. L. A. Graham: What was the date of that?

By Mr. Fulwider: That was also in December, 1936. What was your opinion of it?

A. I knew if these were actual reflections from the tubing collars the maximum error would be less than one joint or length of tubing, or, in the case of that particular well, 20 feet. We would have a reflection from the last tubing collar above the fluid, and we could estimate from the time scale approximately [83] how much fluid would be below the bottom collar reflection; so that at the worst our error would be inside of 20 feet.

Q. You mentioned that you subsequently verified the accuracy of that method. Where were those tests run?

A. Those tests were run in several wells; some in the Taft area, where we had reflections, measured reflection points in the wells. We checked the tubing collar count against the number of joints of tubing, the reflection points, and found that the echoes were representative of the tubing collars. We had a record of the number of joints of tubing above and between the reflection points. My company is still using the Depthograph system and apparatus. We have used it at intervals as required since we first began using it commercially in 1936. Our company is completely satisfied with it; with the result of its

(Testimony of Malcolm Wells Morris.)

accuracy. We would not continue using it if we were not.

Q. Mr. Morris, I don't believe we covered the question of when the Standard Oil Company accepted this collar-counting method as a commercially useful or acceptable method to them. Could you tell us when that happened?

A. February, 1937, during some tests that were made in the Lake View area charts were obtained which had collar reflections on them at well 17; and we had three reflection points whose depths were known in this well. We were able to count the echoes and check it against the number of collars we knew to be in the tubing string above the first reflector and between the [84] various reflectors, and that checked out so that the method was accepted and we first put it to commercial use on our wells, at least, the method was used commercially on our wells first in March, 1937, during a series of tests of nine wells at Mountain View, Abadie No. 1 was retested and Wilson No. 2. These records were accepted as correct. The Depthograph tuned collars deliberately in these tests and the pressures were calculated from the graphs.

They tuned collars by using a length of pipe between the instrument and the casing head, which was about one-third of the distance between collars in the tubing string. That yielded the desired collar echo.

By the Court: What is the length of the tubing?

A. There are two standards which are common-

(Testimony of Malcolm Wells Morris.)

ly employed by our company. One range of tubing averages a little over 20 feet to the joint and the other range averages about 30 feet.

By Mr. Fulwider:

Q. You used the word "tuning." Does that mean tuning collars? Or did you mean accenting the collar echoes?

A. That is correct.

Q. So that they are distinguishable on the graph that you got?

A. Yes. This commercial tuning or accenting of the collar echoes on these later tests was started between March 10th and [85] 15th, 1937. Prior to that date the Depthograph obtained charts showing collar echoes, but they were not doing that deliberately, to my knowledge at least.

Q. And those earlier charts, if I understand it correctly, you were not positive whether they were collar echoes or not?

A. The first chart I saw, in December, 1936, at well 5, in section 5, was represented by Mr. Walker as showing collar echoes. We had no information available with which to check that claim. We obtained information and verified it in February of 1937.

Q. Then, after further proof, in March the company agreed that reports based on that method would be accepted?

A. We requested that he do that henceforth so that we would not have to go to the expense of in-

(Testimony of Malcolm Wells Morris.)

stalling a reflector in our tubing string in the hole.

Q. That was an alternative method that was cheaper to operate?

A. That is correct.

By the Court: What kind of reflector did you put in?

A. Originally we started out using reflectors made of canvas belting. The reflector was cut out of a strip of belting, with a diameter about one inch smaller than the diameter of the inside of the casing. This was fastened to the tubing collar by means of a clamp. These reflectors did not give [86] satisfactory echoes and we abandoned that and made a reflector in that shape out of lengths of old second-hand metal casing. They were about one inch smaller in diameter than the i. d. of the casing. They were flat on top with a rounded edge at the top and bottom; about three feet in length, and they were welded to a tubing collar. We simply took a collar off a joint of tubing, where we wished to install it, and installed this collar on the sleeve of the tubing. It was rounded, in order to facilitate in running and pulling from the well.

Cross Examination

By Mr. Graham: Q. Mr. Morris, in what form did Mr. Walker hand you or the company this information?

A. We stipulated that a copy, a graph of the original graph taken as a part of the test be submitted to our company, together with the form

(Testimony of Malcolm Wells Morris.)

which Mr. Walker had developed for reporting the information. That was done with these first tests that were made.

Q. Do you have copies of those graphs that were given to you when the first tests were made?

A. They are in the files, yes.

Q. Do you mean they are in the files of the company? A. That is correct.

Q. Can you produce those?

A. I can't this afternoon.

Q. Will you please do so? [87]

The Court: Can you get them tomorrow?

A. They are at Taft. It would necessitate a trip to the field, and an investigation of the files.

Mr. Graham: Some time before the conclusion of the trial—

The Court: At the rate we are going I don't know when the trial will be concluded. You will have plenty of time to go to Taft.

The Witness: We have quite a wealth of records of that nature. Can you stipulate the ones you are particularly interested in? It will save considerable time and expense.

Mr. Graham: The ones you have testified about. You said you were present when certain tests were made with the Walker apparatus.

The Court: Which ones do you want?

Mr. Graham: Those that were made in May, 1936; and August and December of that year.

The Court: What is it you would like to have him bring?

(Testimony of Malcolm Wells Morris.)

Mr. Graham: The reports and charts Mr. Walker furnished the company at that time after making those tests.

The Court: Those will be obtainable, won't they?

The Witness: I think so. To my knowledge they have not been destroyed, but I have been away from Taft for four years. It is not the custom of the company to destroy basic records.

Mr. Graham: Your Honor, I would like to know just what it was that Mr. Walker furnished the company. He furnished them with a graph. [88]

The Court: When?

Mr. Graham: I am still speaking about these different operations the witness has testified to, your Honor. For instance, in this that took place in May, 1936, what did Mr. Walker furnish the company?

A. He furnished the company a copy of the graph showing the echo measurements at the well; he furnished the company a copy of his interpretation of the depths that were involved in these tests, tabulated on a form, a standard form, which they had printed.

Q. And the information that was on that form was fluid level, is that correct?

A. Fluid level in all cases; well production; casing pressure; the producing conditions at the well, speed, and stroke, and other information on that order.

Q. Isn't it a fact that the information, quite a lot of it, was given to Mr. Walker by the company?

(Testimony of Malcolm Wells Morris.)

A. That is correct.

Q. In fact, all that Mr. Walker furnished were the fluid levels, isn't that correct?

A. He furnished fluid level and the depth of the fluid level, a copy of the graph on which he based his calculations. He compiled for us, on his printed form, the other information that we wished, to make a permanent record. We were particularly [89] interested in fluid level.

Q. Prior to the time that you saw these demonstrations by Mr. Walker, you had ways of estimating bottom hole pressures, didn't you?

A. We measured bottom hole pressures in wells that were producing under natural flow, under producing conditions, and under shut-in conditions. We measured bottom hole pressures in pumping wells under producing and shut-in conditions by means of a recorder installed below the pump.

Q. Then, in making a calculation of the information that you so received, did you calculate other conditions in the well, as to productivity potentials?

A. Yes, we call it capacity; we calculated the capacity or the productivity index.

Q. You had a formula for doing these things prior to Mr. Walker showing this apparatus to you, or demonstrating it?

A. We calculated the productivity index from pressure measurements. We measured pressure in the well, when it was not producing; that is, the static pressure. We measured the pressure in the

(Testimony of Malcolm Wells Morris.)

well with the well producing at any desired rate, and calculated the productivity index by dividing the barrels of oil obtained with the well producing by the difference in pressure under static conditions and producing conditions. [90]

Q. I will show the witness Figures 4 and 5 of the reissue patent in suit. There are two graphs here; I will ask him if he is familar with them.

A. Yes; we have done that.

Q. And you did that long prior to Mr. Walker coming and making his demonstrations, did you not?

A. That's correct.

Q. How did you compute bottom hole pressures prior to the time Mr. Walker made his demonstrations?

A. We did it in both flowing wells and pumping wells. In pumping wells we made it by installing a depth pressure recorder below the pump. We measured the pressure in the well with the well shut in, and we measured the pressure in the well with the well producing. We gauged the production the well made; calculated the productivity index by dividing the production by the draw-down in the pressure.

Q. I asked you how you plotted potentials. Take, for instance, as an illustration, a pumping well. How did you calculate the bottom hole pressure in a pumping well?

A. We measured it by installing a depth pressure recorder below the pump.

(Testimony of Malcolm Wells Morris.)

Q. So that you used pressure in your calculation?

A. We used pressure under two producing conditions; we used the difference in pressure between two conditions, [91] either producing or shut-in and producing.

Q. Do you get bottom hole pressures in any other way than by measuring it? You do not compute them in any manner from other information?

A. No.

Q. There is one question that is not answered. Will you read that?

A. We estimate bottom hole pressures currently with our current knowledge that has been obtained by accumulation of experience with the depth pressure recorder and with sonic testing equipment. By "sonic testing equipment", I mean by work that has been done by the Depthograph.

Q. I am confining my questions to your operations prior to the time that the Depthograph was used.

A. We have obtained our measurements in pumping wells through the depth pressure recorder.

Q. How did you use the information that you acquired, obtained by this recorder?

A. We used the information in calculating the amount of oil we expected to recover from the well and from the pool, and calculating what the capacity of the well was. If we found that we were not able to produce the oil to capacity with the equipment that we had installed, we were in a position

(Testimony of Malcolm Wells Morris.)

to make changes in the equipment or in our meth of operating that equipment in case we desired obtain more production. [92] "Potential" is broad used by the industry as a rating of the well. It h been used by the oil umpire or oil administrator a factor in determining the amount of oil that well will be permitted to produce. It is not nec sarily synonymous with "capacity".

The Court: "Potential" means what you c convince the umpire your capacity is, where "c pacity" is capacity?

A. That is correct.

Mr. Graham: Q. Prior to the Walker expe ments did you have other ways of obtaining t pressure, except by this pressure recorder that y mentioned?

A. We had no other accurate way of determi ing pressures. We used fluid level data obtained wi the wells shut in and the pumping equipment r moved from the well in estimating what botto hole pressures might be. The results obtained we extremely erratic, due to the lack of knowledge to the amount of gas that was entrained with t oil and to the location of the water column, wat having a higher gradient, higher density than c

Q. Just how did you go about figuring that that shut-in well, for instance, the bottom hole pr sure with a bailer?

A. Well, the bailer was run into the well by t well crew. The crew measured the position of t fluid in the [93] well and if we say, for examp

(Testimony of Malcolm Wells Morris.)

that the fluid leval was at 2,000 feet, and the oil sand was at 3,000 feet, we were in the habit of making an estimate as to the pressure at the bottom of the hole, assuming a gradient from 2,000 feet to 3,000 feet. These assumptions were grossly in error due to the fact that we frequently had foamy oil rather than tank oil, and to the fact that there were variable amounts of water likely to be present in the column. In any given well, if you had a thousand feet of fluid, all but 50 feet of that might be water, or 950 feet might be oil and only 50 feet water.

The Court: I thought you said this morning that this demonstrated that the density was the same all the way down?

A. I am referring now to the fluid level as found in a pumping well when the pumping equipment is out of the hole. There is no pressure on the well head.

The Court: Oh, when the pump is not pumping?

A. And there is no production. It is only when the well is pumping and you are controlling the production rate and the well conditions that your density is the same.

The Court: But when it is idle, I suppose the oil comes to the top and the water goes to the bottom?

A. That is correct; and the light frothy oil comes to the top of the heavy oil. In a pumping well the density is subject—while constant for any given producing condition, [94] it changes for dif-

(Testimony of Malcolm Wells Morris.)

ferent producing conditions in the same well. If you pump a well so as to remove 100 barrels a day and you pump it so as to remove 400 barrels a day, it is generally true that the gradient will be different for the two producing rates but constant for each rate.

The Court: Yes, I understand that.

Mr. Graham: Q. Does the Standard Oil Company still use pressure bombs, pressure recorders?

A. The term "pressure bomb" is oil field slang that is very greatly resented by some of the super-technical men. We employ the pressure bomb or depth pressure recorder.

Q. You referred a while ago to a chart or graph that you had there. May I look at that?

A. Yes. This is a graph of the readings that were taken at Abadie No. 1 between December 29, 1936 and December 31, 1936. It is a plot of fluid level in feet versus pressure of the fluid surface. That chart was prepared by one of my assistant engineers from the graphs that were taken by the Depthograph Company. The graphs showed the echo from the fluid surface. I gave instructions for this curve to be made.

Q. Where did you get the data, or how did you come to have a curve like that plotted?

A. The data was obtained by Mr. Walker on the well. He gave us a copy of the graphs and copy of the usual printed [95] report giving well conditions, his computation of the pos on of the fluid level and pressure of the fluid sur ce. He also

(Testimony of Malcolm Wells Morris.)

included a pencil graph which was a plot of that type. The indication of the constant fluid density was so startling that I had the pressure calculations and fluid level position calculations verified, and discussed the graph with other members of the staff. This graph was prepared under my direction for inclusion in a report which was prepared for the management of the Standard Oil Company. This was prepared in April of 1937.

Q. And it was on the preparation of this report that you became startled?

A. It was on receipt of Mr. Walker's graph. By the time this graph was prepared we had accepted and were using the method of determining bottom hole pressure under producing conditions.

Q. Now, among the documents that you are going to obtain and bring to us here in court you will bring this material or data that was furnished you by Mr. Walker?

A. I will bring everything that is still in the files of the Standard Oil Company.

Q. Will you include a copy of your report to the company?

A. Yes. If the court please, I am taking liberties. This information belongs to the Standard Oil Company of California and not to me personally. I believe it would be essential [96] that a directive be issued that these records be produced. They are not——

The Court: Do you know of any reason why they should not be produced?

(Testimony of Malcolm Wells Morris.)

A. I don't know of any, no; but I just work there.

Mr. Mattingly: Some of the oil companies are very reluctant to have their records used, without subpoenas.

The Court: Well, the records should not be required, even with subpoena, unless they are material and competent, and even there consideration should be given to whether or not there is any disclosure of trade secrets.

The Witness: There are two points I would like to establish here regarding this matter. One is that we are in a war, we are short-handed, we are just overloaded with work incidental to trying to produce oil for the war effort. I would like to keep any requirements down to the bare essentials because it does interfere with our other work. Secondly, this pressure information is held as confidential by Standard Oil Company of California.

Q. As to the particular well?

A. No; as to the pressures at a well because of——

Q. That is, as to each particular well?

A. Yes, sir. The point is that there are possibly legal [97] difficulties that may arise if competing operators or various interests concerned were able to obtain access to the information.

The Court: I will direct you to produce the information and if upon its production in court the company wishes to advance any reason why it should not be disclosed, I will hear their objections

(Testimony of Malcolm Wells Morris.)

at that time. In other words, the information will be here. My disposition will be to require a showing of its materiality. I will give, even then, consideration as to whether or not I will require disclosure of a trade secret. So you will produce them and I suppose that your company counsel—of course, you are not entitled to any lawyer, but, at the same time——

Mr. Fulwider: Your Honor, while we personally have no objection, of course, to them, in the event that the Standard Oil Company should wish to present objections would it be possible for Mr. Mattingly or myself to present those objections together with Mr. Morris?

The Court: Yes; that will be all right. I think you are entitled to cross-examine the witness concerning the matter, because he was examined on them directly. But as far as the results are concerned, they would come under the rule of memoranda made at the time and the opposite side is entitled to introduce them, if we rule strictly, and both only if they are used by the witness. [98]

Mr. Graham: Maybe Mr. Walker has some copies of these records.

The Court: What *are you* interested in is the copy of the records that Mr. Walker made?

Mr. Mattingly: Mr. Walker states that he has copies of some of these records that Mr. Graham has asked for, but not all of them.

The Court: I am sure that counsel, generally, will try to find what this defendant's counsel wants

(Testimony of Malcolm Wells Morris.)

to see, without embarrassment to anybody's trade relationships.

You will be notified to return at some specific date. Some arrangement may be made to inspect these documents, but you are under no obligation to show the cards; you are under obligation to produce them.

Mr. Graham: With the understanding that we have not finished, he may be excused at this time?

The Court: Yes.

Redirect Examination

Mr. Fulwider: Q. Prior to the time the Walker method or the Depthograph method and equipment, such as you described this morning, was there any way of accurately measuring fluid levels in pumping wells without shutting them down?

A. I am not familiar with any way. [99]

Q. In your testimony you used the term "sonic methods." Are there any other methods or apparatus on the market for determining fluid levels and other subsurface measurements besides Depthograph, that are known as sonic methods to the trade?

A. The term "sonic measurement" is used on paper in depth pressure data in the determination of well potentials in California to denote tests made in California by the Depthograph method and the Echo-Meter method. It is used as a general term, covering the two methods.

Q. That is a generic term used in the industry to cover both methods?

(Testimony of Malcolm Wells Morris.)

A. That is correct. The Echo-Meter method is now offered by the Halliburton Oil Well Cementing Company.

Recross Examination

By Mr. Graham: Q. Do you know Harold Wyatt?

A. I am acquainted with Harold Wyatt, yes.

Q. Do you know Mr. Lehr?

A. I am acquainted with Mr. Lehr.

Q. Did you ever hear of anything that they developed for determining fluid levels?

A. I met Mr. Wyatt in 1936, and Mr. Lehr in 1937. I had heard, previous to the time that I met the two gentlemen, [100] and previous to the time that Mr. Walker came to our office and explained the Depthograph method and apparatus, that Lehr had been doing experimental work with the Shell to determine the position of fluid level by introducing a pressure wave into the casinghead of a well. I had no knowledge as to what apparatus he used.

The Court: Or the results? Did you have any knowledge of his results?

A. I had no knowledge of his results.

Mr. Graham: Q. Did you know enough of the Wyatt and Lehr apparatus to know whether or not he used a pressure impulse chamber, like this tank you said Mr. Walker had?

A. I was not familiar with that. At that time you can appreciate, I would imagine, they were keeping this a confidential topic; they were in the

(Testimony of Malcolm Wells Morris.)

development stage, and I heard of it only in general terms through friends of mine in the Shell organization.

Q. You heard of some work being done also at the Union Oil Company?

A. I was not familiar with any work that the Union was doing at that time.

Q. You did not know of that work prior to the time Mr. Walker came to you?

A. I did not know anything about the Union Oil Company work until in 1937, at which time we were approached by the [101] International Geophysics Company regarding a method of testing wells, which is now known as the Echo-Meter method, and that representative told me that preliminary work had been done in Union Oil Company wells.

The Court: In December, 1936, when you learned from the tests on the Abadie well, by the Walker apparatus, that the fluid in a pumping well had the same density throughout, had you heard of any method prior to that time of ascertaining or computing the density of the fluid in a flowing well?

A. In a flowing well we had customarily been measuring the gradients directly with our depth pressure recorder.

Q. That was at the pump?

A. This was in a flowing well; no pump to it.

Q. I meant a pumping well.

A. We measured the pressure at the bottom of the pump in the well at a single point in the well.

(Testimony of Malcolm Wells Morris.)

We estimated; we assumed a gradient in transferring that pressure measurement at one point to the sand, in estimating the pressure at the sand. It was customary with me at that time to assume a gradient equal that of tank oil corrected for the temperature at the bottom of the well.

Q. Prior to that time had you heard of any method of ascertaining that; I mean, prior to this Walker method in the Abadie well, had you heard of any method of ascertaining [102] that density of fluid in the well? A. I had not.

Later in the trial, the following colloquy occurred:

Mr. Mattingly: Your honor, Mr. Morris has come into the court room today with the various records Mr. Graham requested him to bring, and they have been submitted to Mr. Graham for his inspection and they are in the court room for the inspection of the court and counsel, but the Standard Oil Company has requested that they not be made exhibits in the case where they may be open to the public.

Mr. Graham: Your Honor, we appreciate the production of these, but the one we wanted particularly was the pressure depth chart that Mr. Walker gave to the Standard Oil Company, and Mr. Morris, from which he made up the chart that he testified about, and these others, I can't see that they will add anything to the graphs—that's what they are; in other words, the record made by the machine of

(Testimony of Malcolm Wells Morris.)

what is already in evidence; consequently, I do not believe we have any further questions to ask Mr. Morris.

The Court: You have examined the records that you desire?

Mr. Graham: Yes, we have examined these documents which they have produced.

The Court: You don't desire any of them?

Mr. Graham: No, your Honor. I will just explain to the [103] Court that they are graphs like a lot of these that have been introduced, and have a lot of data about the wells of the Standard Oil Company, and it is going to take ten days if we try to get that all straightened out, and as I say, they are not of sufficient importance to go in. [104]

EMMET WALTON GILBERT

called on behalf of the plaintiffs, testified as follows:

My address is 118 South Croft Avenue, Los Angeles. I am a mechanical engineer, a graduate from Cal. Tech. in 1923. I am employed at this time by The Shell Oil Company, Inc. I went to work for them in 1927 in the geological department. My duties were various. I ended up there as a research engineer working on special development problems. During that period of time with the Shell Company I designed and built equipment for use in surveying wells. I developed an instrument for

(Testimony of Emmet Walton Gilbert.)

determining the bottom hole course of oil wells, the inclination and direction of drift. I left Shell in 1931, and was gone until 1934, when I was called back. I have been with them since in the field engineering department. I was an equipment engineer, concerned with the development of drilling and production equipment, the selection of equipment, and the development of improved equipment. My duties include keeping abreast of developments in the industry. That is essentially the purpose of the job. I did work that might be classified as research. I developed an instrument for measuring the work done at the bottom of a pumping well, getting dynagraph records down there, which gave the work, the stroke length, and fluid load on the pump, and gave us a much better insight into the pumping action than we had previously. I am a member of the American Petroleum [105] Institute. I have held most of the offices that fall in my line of work. I finished up as National chairman of the Drilling and Production Practice Committee. In connection with that work I had occasion to supervise or initiate research work done by other companies. I have attempted to summarize the developments that were current, and in such sense initiated developments along lines that seemed necessary for the proper development of the industry.

By Mr. Fulwider: Q. Can you tell me whether, prior to 1936, the oil industry as a whole, or as

(Testimony of Emmet Walton Gilbert.)

you were familiar with it, recognized the value of determining subsurface pressures in oil wells?

A. Oh, yes; C. V. Millikan of the Amando Company developed a recorder which was first used, I believe, in 1930. There was quite a program on bottom hole pressure work going forward under his direction in 1931, and the industry, as a whole, in the years that followed that developed a very clear conception of the need for bottom hole pressure data.

Q. Up until the latter part of 1935 was there any method or apparatus for determining bottom hole pressures in a pumping well, without removing the pumping equipment?

A. I never heard of any. I am familiar with what are called depth pressure recorders or pressure bombs in a general way. They were the first apparatus ever used for bottom hole pressures. The first recorders did not have clocks, and could not have been [106] used on a pumping well. It was after they had put clocks on those recorders that they could be put on a pumping well, but the rods had to be removed and the tubing, of course, in order to make a run. There are particular advantages to determining bottom hole pressures while the well is pumping; particularly, there are wells which don't reach a steady producing condition in perhaps a day or two days, in some cases, and when you run the recorder in, I think the maximum time that recorder is effective is 72 hours. You can't get more than one or two steady rate read-

(Testimony of Emmet Walton Gilbert.)

ings often in that time, and then you are not too sure of yourself. When you are at liberty to maintain a steady condition as long as you please you can assure yourself of having reached a steady condition before proceeding to another steady rate. That is possible with the Depthograph equipment.

I am acquainted with Mr. Cranford P. Walker. I am familiar with his equipment called the Depthograph equipment. He ran tests and did work for the Shell Company. I first became acquainted with Mr. Walker's Depthograph work either in the latter part of '35 or early in 1936, and I can't be sure. I was in more or less close touch with him during that period of time, say, from the early part of 1936 up through 1936 and 1937. I instructed him to keep me closely advised when he did a job.

Q. Can you tell us briefly what apparatus and method [107] Mr. Walker was using in the early work, say, in 1936, the spring of 1936?

A. I am no adept at verbal descriptions, but he had a pressure flask for initiating pressure-impulse in the casing of the well, and he was at that time using reflectors down the hole as a means of calibrating the velocity of the waves thus set up. The wave reflections were reflected or hit a diaphragm at the surface and the diaphragm actuated an oscillograph and he depthographically made a record of the vibrations thus recorded through the diaphragm. There were other details but that is essentially what he did. The graph that he got by

(Testimony of Emmet Walton Gilbert.)

that, gave him a record of the depth to the fluid level.

The Court: When was that?

A. Well, I wrote a report showing that which was published in our company records in October, '36, but I think that was probably going on at least five or six months prior to that.

Mr. Fulwider: Q. And by the recording of those fluid levels he determined bottom hole pressures?

A. Yes, he used that data very effectively.

Q. Can you tell me did Mr. Walker advise you or disclose to you during that period of time anything about fluid densities?

A. I think it was a surprise to most of us that the gradients that he recorded were so straight. The ability to extrapolate his data was obvious after you had seen his record. [108] Now, we had no previous conception that the density-depth relationship would be as easily projectable as it was. I think nearly all of us were much surprised at that discovery.

Q. You mean his discovery of that relationship?

A. Yes.

The Court: What relationship?

A. The relationship, your Honor, between pressure and depth in the gas-liquid column in the annulus.

Q. In the fluid? A. Yes.

Mr. Fulwider: Q. You mean of the density of the fluid itself, that is, the mixture down in the well?

(Testimony of Emmet Walton Gilbert.)

A. The fluid mixture; yes.

By the Court: Q. Explain a little more about what you mean that you had no idea that the gradient was——

A. Your Honor, an offhand conception of the thing might be something like this: The deeper you go the greater the pressure and the smaller would be the space occupied by a certain amount of gas, and you might set up a mental conception of going down there, the gas being progressively compressed and occupying less and less space.

The Court: That is in the annular space in the tubing?

A. Yes. As a matter of fact, that gradient is quite regular and, for all practical purposes, within the limits of accuracy of a straight line. [109]

Q. The reason you say that, the ordinary conception is likely to be that the deeper it is the greater the density, is that right, because the greater the pressure?

A. Yes. Of course, we know now as a result of his work that it is more or less directly related to the depth; that it is a straight line relationship. If you go twice as deep it is twice as dense—I mean, the density is a uniform density with depth. May I change that? That is not right.

Mr. Fulwider: Go ahead.

A. It is a straight line relationship. You would expect—we were led to expect something quite differently.

The Court: Q. What were you led to expect?

(Testimony of Emmet Walton Gilbert.)

I mean, what did you believe before you discovered that?

A. Well, I wouldn't have believed that you could get an easy curve that could be easily projected.

Q. Well, I still don't know what that means. I know what "curve" or "easily projected" is, but what has that got to do with the density of the fluid?

A. Well, when I referred to a curve I meant the density with reference to depth.

Q. Yes, I understand your curve that way. You found out after these experiments and his discoveries, or whatever it is he did, that the density of your fluid is more nearly uniform than you had expected, is that correct?

A. That is correct. [110]

Q. Well, why didn't you expect that?

A. Oh, probably poor engineering.

Q. I mean generally in the industry?

A. I can't speak for other people in the industry. I know that I was surprised and I have met several other individuals who were equally surprised, because we would have been led to expect that, as you go deeper the same gas would occupy less space.

Q. Due to the weight of the gas itself?

A. The column above.

Q. In the column of water and the column above it? A. That is right.

Q. What does this show, that it does not occupy less space?

(Testimony of Emmet Walton Gilbert.)

A. No; it occupies less space, but in doing so it does not have a rate of gradient equal to most——

Q. That is to say, it does not occupy the same, that is, relatively less space according to its greater depth, or it does occupy relatively less space according to its greater depth?

A. Well, apparently as you go deeper the weight of gas per cubic foot increases in such a way that the gradient is, for practical purposes, a straight line. It is a constant gradient, more or less.

The Court: I have seen these charts around here. There [111] is one over there on that board marked Fig. 3. Have him go down there and explain, or have somebody explain what that means.

(The witness refers to Fig. 3 of Reissue Patent 31,383).

Well, here we have a relationship between the fluid level and the pressure on the fluid level surface in pounds per square inch. If you depress the fluid level to this point here, then the pressure would be this pressure down here.

The Court: Would be greater?

A. Would be greater, but the slope of this line is constant within reasonable limits.

Q. Constant in all wells?

A. No, no; in this particular well for this one steady rate condition. We are now pumping along at some definite barrels per day rate and some more or less constant——

Q. The pressure would be greater at the second point? A. Yes sir.

(Testimony of Emmet Walton Gilbert.)

Q. What would reduce the fluid level because you would have to put more weight on the column, wouldn't you?

A. We impose gas pressure from the surface.

Q. And is there something unusual about that? I mean, you put more pressure on it and there is more pressure on it; that is what I understand you to be saying.

A. No. What I am saying is that I did not suspect this would be a straight line relationship, your Honor.

Q. What did you expect it? [112]

A. I expected it to be very much curve in it.

Q. Why?

A. Because, as you go deeper the gas—I mean the cubic volume of gas will occupy less space the more pressure it has on it, according to Boyle's law it is inversely related to the pressure, or volume occupied by any——

Q. Then you thought from that experiment, under your previously existing theories, it should have resulted in a curved rather than a straight line?

A. Yes; or more of a curve than we have any reason to believe exists there. If it had been a severe curve, your Honor, we could not have taken one or two readings here and usefully extrapolated them down to this point, which is what we desire, the pressure at the pump.

Q. Why would it have been a curve?

(Testimony of Emmet Walton Gilbert.)

A. Of course, your Honor, you are asking me to explain my own ignorance and it is not very pleasant.

Q. No; I am not. I understood that in the industry those with whom you talked had the same idea.

A. Yes. I have had the experience, after I was so thoroughly acquainted with this, of having to explain it to other engineers and trying to rationalize it. It was something that was not easily grasped or quickly understood. [113]

Mr. Fulwider: Q. What kind of a curve would you have expected to get prior to the time Walker discovered this constant density condition, referring to this chart here, Fig. 3?

A. It would have been a concave affair like that, rather a steep change.

Q. With what you would have expected from your previous knowledge?

A. Probably previous lack of knowledge.

Q. Well, summarizing it, then, if I get this correctly, the fact that that relationship was substantially a straight line relationship was a surprise to you. From your previous work you had been led to believe that it would have been a curve if you plotted those results? A. Yes.

The Court: I don't know why it would have been a curve. I can understand why you would expect that it would go down vertically, but why would it come down to the bottom of the curve there and taper off again, upon what theory?

(Testimony of Emmet Walton Gilbert.)

A. Well, if a gas occupied less space, your Honor, since you would not have any voids down there you might have more liquid in the space not occupied by the gas.

Q. Well, I am describing an arc here now. When it comes down here it begins to taper off, doesn't it, and it comes over horizontally instead of vertically?

A. If we could conceive of no gas passing up through this [114] column and we had a uniform mixture from top to bottom, with no motion in it, you would get the kind of thing I am talking about. If we had little rubber balls, each filled with that same mixture, piled one on top of the other, then you would get a much greater curve than you have here.

Q. Let me see. The reason we expected a curve was because it would reach its maximum some place down there on that curve, is that right, the maximum amount that the gas could be compressed into?

A. Yes; there is such a maximum where it would go into solution, so far as that goes.

Q. And otherwise it would have continued on?

A. A curve down to that maximum, yes.

The Court: I see. I think that explains it a little better.

Mr. Fulwider: Did Mr. Walker ever compute fluid levels by counting collar echo peaks on the graphs which he obtained with this Depthograph?

A. Yes.

(Testimony of Emmet Walton Gilbert.)

Q. Will you tell us any conversations that you had with Mr. Walker about the methods of counting collars?

A. Well, I think that I knew about his use of that method shortly after he started to use it, but I can't quote you an exact date. It was subsequent to October, 1936, when I wrote my first regular company memorandum on the subject. It [115] was some time in 1938 that I wrote another memorandum that covered that subject of counting collars.

Q. Can you tell us very briefly what that method consisted of?

A. It was a method of selecting the tube length from the well to the diaphragm in order to reinforce the waves reflected from each collar. And then he determined something like one-third the distance between two collars was the desired length to have between the well and the diaphragm—the well head and the diaphragm, and whatever the details of that are, he was able to so regulate the space there that he reinforced the collar reflections to such an extent that he could reliably count them and so determine the velocities of the waves traveling up and down the annular space.

Q. Prior to the advent of Mr. Walker's Depthograph equipment was there any method, to your knowledge, for determining fluid levels in a pumping well other than the pressure bombs and other systems which required the shut-down of the well?

(Testimony of Emmet Walton Gilbert.)

A. We had a rudimentary Lehr-Wyatt device that we used or attempted to use for that purpose.

Q. Will you describe that very briefly as to what that consisted of?

A. It amounted to simply a flask that either had pressure in it, or if you were operating with a well casing pressure you could simply fill the flask and start a vacuum wave down it. By [116] either of those methods you would start a wave which can be reflected, and then in the earliest expression of this device we simply had an escape of gas from the casing and a man would hold his hand in front of it and when a puff of pressure came back that was timed from the inception of the wave and we got a very rough notion of the reflections. It was quite inaccurate. It took a man with a sixth sense to be sure that he was getting the reflection from the fluid interface and not from something like a tubing catcher or the top of the liner. We were never sure of our results and we were glad to have something more authentic and useful.

Q. Did your company ever put any kind of a recording or indicating device in the Lehr and Wyatt apparatus?

A. Yes; I believe they experimented—not with a recorder, because it never got that far, but they did put a diaphragm with a needle attached to the diaphragm. Your needle would jump up so that we had a visual rather than a factual indication of the return of the wave.

(Testimony of Emmet Walton Gilbert.)

Q. Were the results that you obtained from that satisfactory?

A. No. They were no more satisfactory than the first. The Shell Company operates a Depthograph machine now. We have had it—I don't remember exactly when we got it, but it is over a year ago and we have used it to very good effect ever since we have had it. It is working very hard now. It is one of Mr. Walker's machines. [117]

Q. What is the arrangement between your company and Mr. Walker for the use of that machine?

A. We rent it. We have an arrangement by which we, I think, pay the lump sum covering the cost of it and also pay a rental. It is operated by our own people. That machine which we are now using is similar to the equipment which I previously described in all essential details. It has some minor improvements, but it is the same practical apparatus.

The Court: The same as what, Wyatt and Lehr or what?

A. No; as developed by Mr. Walker in the early part of 1936.

Mr. Fulwider: Q. As described by you in your previous testimony? A. Yes.

Q. Are you familiar with the International Geophysical apparatus called "Echometer"?

A. I have seen it but I can't say that I am very familiar with it.

Q. At the time your company made arrange-

(Testimony of Emmet Walton Gilbert.)

ments to run this Walker Depthograph machine did you make any investigations of such other equipment as there was on the market for accomplishing the same thing?

A. Yes. There were only the two makes, the Echometer and the Depthograph. I did not have an opportunity to test the two [118] instruments at the same well, which would have been the most definite method of approach, and such investigating as I did was limited to obtaining opinions of people who had used either one or both, in reaching a conclusion on the basis of information obtained.

I would think that we had this Depthograph over two years.

Q. Has the Depthograph machine which your company operates always proved satisfactory?

A. There are limitations to the use of any instrument you can think of. There are instances when the Depthograph is not applicable, but they are very few, and it has proven very useful to us in our pumping well practice. I think it is very exceptional when we find an instance where we can't get useful results with the use of the Depthograph.

Cross Examination

By Mr. Graham: Mr. Gilbert, in this report that you made in October, 1936, do you recall whether you said anything in that about tubing collars?

A. I recall that I did not say anything about tubing collars.

(Testimony of Emmet Walton Gilbert.)

Q. When was it that you found out about these tubing collars from Mr. Walker?

A. I can't tell you exactly.

Q. Was it prior to that time or subsequent?

A. No; it was subsequent to that time. [119]

Q. As far as the operation of that Wyatt and Lehr apparatus and getting reflections from the fluid level, could you get anything more as far as getting the fluid level is concerned with the Walker apparatus than you did with the Wyatt and Lehr?

A. Yes. You could have some certainty that you were getting the fluid level and not the reflection from something else. It made the difference between being sure of yourself and being very uncertain about yourself.

Q. Why do you say that? You got a puff, in the one instance that you spoke about, and it was a matter of computing time, was it not?

A. Yes; and I said we got a puff but only the adept could tell you whether it was one puff or five puffs. At times it was quite indefinite and, as we later learned, sometimes the actual reflection from the interface was of lesser intensity than the reflection from some other obstructions, and that the result, you had no means of checking which reflection you were reading.

Q. Then the difficulty with the Wyatt and Lehr apparatus was a proper recording mechanism, is that correct?

A. That was a part of what was necessary to accomplish what we later accomplished.

(Testimony of Emmet Walton Gilbert.)

Redirect Examination

By Mr. Fulwider: Q. When you use the term "interface" you mean that as being the fluid surface, do you not? A. Yes? [120]

RICHARD W. FRENCH, JR.

a witness called on behalf of the plaintiffs, testified as follows:

My address is 1122 Milan Avenue, South Pasadena. I am a graduate engineer from the University of Delaware. I graduated in 1929. After graduation, I served a year with the General Electric Company, and studied engineering, doing special mechanical testing work, taking their advance engineering and administrative courses, following which I served two years and two months in the army air corps as a flying cadet, on active duty, after which I have been working in oil; that is, since February, 1933, employed by the Continental Oil Company. Starting as a roustabout in the field, in 1933, I have worked in addition, as a gang pusher, in field terminology, compressor plant engineer, gas dispatcher, field production engineer. In 1936, in April, I was promoted to the job of production engineer for the Continental Oil Company west of the Rockies. I now handle all the engineering supervision or work connected with the drilling in exploring and developing oil properties

(Testimony of Richard W. French, Jr.)

to produce oil and gas. One of my duties is to keep abreast of the development in the production and drilling problems in the oil industry. That is an important, implied duty at least.

I have discussed developments with engineers of other companies so as to be familiar with what they are doing. That is, carried on also in formal discussions, in the course of the [121] *the* activities of the American Petroleum Institute and other professional organizations. I am not a member of the American Petroleum Institute right now. I have been. I think I am a little disconnected at the present time.

I have had occasion to write or collaborate on papers relating to subsurface data. In 1941, I was chairman of the National Production Practice Committee of the American Petroleum Institute, and a year before for the California District, in the same function.

Mr. Fulwider: Q. Prior to 1936, did the oil industry recognize the value of determining fluid levels, fluid densities, and subsurface pressures in oil wells?

A. Yes, I think they and we had recognized it long before that. Without those data it is impossible to determine whether you are producing an oil well efficiently, and whether you are getting all the oil that could be taken from it, and to know the exact behavior.

The Court: Why?

(Testimony of Richard W. French, Jr.)

A. Your Honor, without being able to mathematically evaluate how much oil can come in the bottom of an oil well, and having knowledge only from what you get out of the top, you are left a blank in your knowledge, and can't tell whether you are getting all the oil that is coming out of the bottom, from the top indications. An oil well has various rates between the low, intermediate and full quantities that [122] enter the bore hole from the oil reservoir, and without this data you can't be informed as to the quantity; you can only form an estimate of it, and you have no mathematical estimate as to whether you can get 200 barrels a day, if you have the necessary equipment, or all you are getting is 80 barrels a day.

The Court: Does this have anything to do with determining whether or not you could read pressure in sand?

A. Not directly. I would say it has some corollary in analyzing this thing, whether you could read pressure in sand, but not directly. I think the main importance is the one which we are dealing with today. We have a very strict practical problem in the field on equipment today. We can't get any more steel than we need. In fact, the situation is stringent, but we do need all the oil we can get. And we do have the fields now where it is important to use the pumping unit in accordance with the capacity. Some wells have a capacity of 100 barrels and some have a capacity of 500 barrels. We put

(Testimony of Richard W. French, Jr.)

them on wells so they can pump the fluid that they are capable of making. The only way I know of fitting that equipment to the well's natural production capacity, so that you can get the most out of it, is through data like that.

The Court: What difference does it make what the density of the fluid is?

A. Without the density it is impossible to calculate [123] the pressure. The pressure is the key to telling how much oil you can get from an oil well.

The Court: That is, the pressure under the fluid; that is what you are talking about?

A. Well, the pressure under the fluid or in the hole, 10 feet, 20 feet, or any distance. If you know the density you can take the depth and calculate what the pressure is at that point.

The Court: Why?

A. Because it is just a matter of determining the pressure exerted by any fluid column. The air in this room is fluid, but it is so light we don't think of it as such. It is a substance that is capable of exerting a definite pressure. You take a column of water in a pipe, for instance, 20 feet high, you would be able to calculate the pressure at the bottom, knowing that the water has a pressure of 62½ pounds. Any time you are able to tell the density of a fluid, then you are able to determine what the pressure is in that fluid, whether it is a mile down or a foot.

The Court: You mean it is the same all the way down?

(Testimony of Richard W. French, Jr.)

A. No, sir. The pressure varies with the depth. It can't be the same with a common density fluid.

The Court: If you had a 6-inch pipe, the density would be the same all the way down? [124]

A. Yes. I understood you to say, is the pressure the same? In that case the pressure is the same and your density is constant in that case.

The Court: The density is weight?

A. The density is an expression of unit weight, the weight per unit of measurement.

The Court: The greater weight you have the greater the pressure. A. Yes.

The Court: How do you express density, in inches?

A. No. There are several ways of doing it. In this work we express it as a gradient. In other words, we express it as the net result of what we are trying to get, the pounds per square foot. The square inch pressure you get each foot you go down in the hole is expressed, then, as a gradient. The gradient for plain water at ordinary temperature would be about .434. In other words, every foot you go down, with plain water at ordinary temperature, you increase the pressure .434 pounds per square inch. Oil is less dense and instead of increasing the pressure .434 pounds per square inch for every foot you go down in the well, it would be .33 for ordinary oil. It is a lighter fluid.

The Court: How can you tell what the pressure is if you don't know the character of the fluid?

[125]

(Testimony of Richard W. French, Jr.)

A. That is just it. You can't.

The Court: You determine whether it is mud or oil by the pressure?

A. No. In this case, that is it; you can't tell the pressure unless you know the type of fluid. Therefore, you have to know whether it is plain water, whether it is mixed oil and water, whether it is gassy oil, which might be quite light——

The Court: And you can tell it by displacing it?

A. That is right.

The Court: And by the method which the plaintiff is using?

A. Yes, in general, I don't know if he has given any specific data, but in general his method is used exactly like that.

The Court: That is what they are quarreling about here, the method.

A. That is the key to the whole problem. It is easy to predict pressure if you know what fluid you are dealing with.

The Court: And you can find what fluid you are dealing with by pressure?

A. That is right. You find the density, then you are able to predict the pressure and very closely calculate it.

The Court: As well as the gravity?

A. Yes. Gravity is another expression for density. It is in different terms. There is another one; specific weight. [126] In other words you are just mathematically rearranging the figure. It is the same thing.

(Testimony of Richard W. French, Jr.)

Mr. Fulwider: Q. You are familiar, are you not, with the apparatus known as a depth pressure recorder or pressure bomb?

A. Yes, that was used prior to 1936.

The Court: What is that apparatus, now?

A. What he calls a pressure bomb we call a subsurface pressure recorder. Your Honor has probably seen pressure gauges on boilers and pieces of equipment.

The Court: Yes.

A. We wanted similar equipment to put down an oil well, but you have too small a diameter of casing to get it down in the earth a couple of miles. So we built an instrument in a cylinder case, about that big in diameter and about that long. It is a rather precise pressure gauge, nothing more, except it draws a little graphic record of the pressure.

The Court: You run that in the oil well?

A. Yes, you may at times, when you don't have a pump, run it on a wire line. Then that pressure gauge records the pressure at the depth you stop.

The Court: At the depth you stop?

A. Yes. Then you can run it at different depths and get pressures every hundred feet in the oil well if you wish.

The Court: That is, get the information that this method gives you? [127]

A. Yes. They are both derived at the pressure. However, running this instrument on a wire line, it is not possible when you have the hole full of

(Testimony of Richard W. French, Jr.)

pumping equipment. It is only in flowing wells where you don't have the pumping equipment.

Mr. Fulwider: Q. A pressure recorder can't be used in a pumping well while it is pumping?

A. Well, the pressure can be run in a chamber below the pump.

The Court: But you have to pull out the rods and pump?

A. Yes, you have to take the rods out and put them in again, and sometimes pull the tubing, too.

Mr. Fulwider: Q. Were there any other methods, to your knowledge, that could satisfactorily measure subsurface pressures prior to 1936, other than this depth pressure bomb or recorder?

A. Well, the word "satisfactorily"—I would have said no, but with the word "satisfactorily", I did read of another experimental device for determining pressures in a well without pulling it. They never, to my knowledge, used it commercially until the last couple of years, and then only in very shallow wells. Just from reading in the literature, I recall an article which told of the Gulf Oil Company and Midcontinental running a piece of small copper tubing perhaps 1/8 of an inch in diameter, a quarter of an inch in diameter, into wells—conceivably it could be on the bottom of the tubing and the casing—and using this [128] device to lower the tubing to a certain depth. They pumped hydrogen, I think, through the tubing until they reached an equilibrium pressure, which meant that the tubing was full of gas and had

(Testimony of Richard W. French, Jr.)

forced all the liquid out. Then by reading a pressure gauge and knowing the density, they could calculate the pressure. But that method has never been used mechanically; it is very difficult; except in the last two years one experimenter in California did use the same method in a couple of very shallow wells; I think 1600 feet deep, or something like that; but I have never heard of any deeper ones or any practical use, because of the mechanical difficulty. If you put a small copper tubing down a deep well you are liable to get it wrapped around and never get it out. And there is, also, the mechanical hazards in trying to put it down near a pump, where we want to get a pressure in a pumping well, because the common practice in oil fields is to put what we call a tube catcher, which is a safety device—we put that quite a ways above the pump, and that would ordinarily preclude putting this delicate gauge down to it. So that device, while I have heard of it, I have not used it or know of anyone that has used it, except in the few shallow wells.

The Court: You heard of it when, in 1936?

A. I think so. I think it was in the engineering literature prior to that time. But I don't know of anyone using that. Whether it was ever put in a well, I don't [129] know. It could be found out, probably.

Mr. Fulwider: Q. Do you recall whether that was an article by Stanley Gill in the Gulf Publishing Company—This is a copy of one of the pub-

(Testimony of Richard W. French, Jr.)

lications which was cited by the defendant in his answer.

Mr. Graham: That hasn't been offered yet, your Honor.

The Court: All right. Let's mark it for identification now. K for identification will be described for the record as a *bookley* of prior publications compiled by the defendants. We will describe this as articles by Wilde and Moore, Gill, Hawthorne, Ihrig, Christie, Nix, Millikan and Vietti. You are referring now to the articles by Gill.

Mr. Fulwider: Referring to the article by Gill, in Exhibit K, do you recall whether or not that is the article that you read which you have just described?

A. It is the identical equipment. I notice that this is a Gulf publication. I may have read it in one of their magazines, but it is the exact equipment I spoke of.

Q. If I understood your testimony correctly, to your knowledge, that had never been practically used until very recently, and then only on shallow wells? A. That is right.

The Court: What is the date of the publication?

A. On the second page it says "Oil Weekly, April 4, 1932". [130]

The Court: It is stipulated that that is the publication date of that article?

Mr. Fulwider: We are agreeable to stipulate to that, yes.

(Testimony of Richard W. French, Jr.)

Mr. Graham: Can we at this time stipulate to the publication date of all these articles at once?

Mr. Mattingly: Yes, we don't question the publication.

The Court: Let us get the dates while we are at it.

Mr. Mattingly: The Wilde and Moore article, your Honor, is a publication dated June 30, 1931. It was published in the transactions of the American Petroleum Institute. Hawthorn has a publication date of January, 1933. That was published in the transactions of the American Institute of Mining and Metallurgical Engineers; that is usually abbreviated "A.I.M.E."

The Court: The Tucker articles of The Royal Society comes before Ihrig in this book.

Mr. Mattingly: January 5, 1923.

The Court: Ihrig is October, 1935?

Mr. Mattingly: That is correct. The Ihrig was published in the Oil and Gas Journal. Christie was a publication of the A.I.M.E. and was published in 1932. Millikan was published in 1931, American Institute of Metallurgical Engineers. Vietti was published in 1931, again A.I.M.E. Nix, in the A.I.M.E., and the year is 1932.

The Witness: I am acquainted with Mr. Cranford P. Walker, [131] and with his apparatus and method, which is known as the Depthograph equipment. They are in general use. I am unable to name the date I first became acquainted with Mr. Walker's equipment because we heard of this new

(Testimony of Richard W. French, Jr.)

equipment, and then we knew someone who used it, and finally used one ourselves and it received increasing use; as I recall, we first began hearing of its use, in my own case, early in 1936. My company has had a great deal of work done by Mr. Walker and his Depthograph equipment. That work has been satisfactory.

Mr. Fulwider: Will you explain very briefly your conception of the Depthograph equipment; how it operates, so we will know what we are talking about?

A. This will be a feeble explanation compared with some of the others, but it is equipment that contains a high-pressure gas chamber which through a quick-opening valve throws a pressure wave between the tubing and the well, ordinarily a pumping well. They have a device for recording the time of this initial impulse on some type of oscillograph or a type of camera with timing integrated into it, which records pressure waves. I am not competent to say whether it is sonic or ordinary, or what mode of pressure waves. We can make a record on the Depthograph, and record obstructions in its path, even on collars now, so you are able to not only get a record which would give [132] the velocity, but you can also find the spacing of all the interruptions in this annular passage. In other words, spacing on collars and tubing catchers. In the early days, I have heard, people put on special markers to detect it.

(Testimony of Richard W. French, Jr.)

The Court: And you calculate those pressure waves, the speed of them by the sound?

A. No, it is my understanding that the velocity varies with the density of the gas, which, of course, varies with the pressure and one thing and another.

The Court: Does the velocity of sound vary with the density of the medium through which it travels?

A. I should have boned up on my physics. I believe it does. I think the velocity of sound which is being associated in present aircraft propellor speed at the tip, I believe that is different in high altitudes, because of the much lower density; but an apparatus, at any rate, having this high-pressure gas cylinder to make a wave on an oscillograph, to time its start and finish with every variation which is caused by the interruption below the annular space, and it does make a record from which you can calculate the information I have just described.

The Court: When you calculate that information what speed do you apply to the pressure impulse?

A. To simplify this troublesome question of gravity, the simpler method, the one we use now, is this: When we put the [133] tube in the hole, we measure carefully and count the collars, and we know how far apart the collars are that are used, and don't have to worry about the velocity, because we have actually had a record or count of the collars. Say we had twenty collars, and they were twenty feet apart, and it takes 1/10th of a second

(Testimony of Richard W. French, Jr.)

for the wave to pass, we can then calculate the exact velocity.

The Court: Whether you know the density of the fluid in the annular space or not?

A. That's right.

The Court: What standard did you take to measure the return of the sound before you counted collars, the standard of sound?

A. No. My company has, I believe, a complete record in the field of what we put in the hole, and there was a method we had of actually determining the velocity for the particular gas in the well, by having a fixed target. Perhaps they would run an obstruction in, and check the well, and they knew what depth and by timing the wave to that obstruction and back, they could determine the velocity.

Q. When you say "they" could determine, you mean Walker, and the Depthograph Company, do you not?

A. They are the ones I had experience with. Instead of saying "They" perhaps I should have said it was possible to do this.

Q. This method you have just mentioned, counting collars, [134] and comparing the time allotted between the time of the known reflector and unknown, to the fluid level, those were the two methods used in determining fluid levels? A. Yes.

The method used by Mr. Walker in determining the bottom hole pressure from this data he got on his chart which showed the fluid levels was as follows:

(Testimony of Richard W. French, Jr.)

The first step was to determine what the fluid level was. The fluid level is important. It marks the difference usually between the two columns of different densities, to be added up to get the pressure down below. Below the fluid level you have a much denser fluid pressure, of perhaps oil and water. Then you get the pressure determination, and make the inference about what its density is, whether it is heavy or light, or it is partly oil, or partly water or partly gas. So the next step is to determine what the actual density is below the fluid level. I might remark that before that we had to estimate what it was under actual conditions, and we would stop the well at a certain point, and measure the fluid level as the well normally operated. Perhaps it was 1000 feet down in the well to the casinghead, and ordinarily a lot of gas would separate from the oil in the well, or escape, or be taken off in the gas meter in the annular space between the tubing and the steel lining. So the valve which lets that gas escape is partly closed by a regulator, and as it is closed the pressure backs up in the casing, because the [135] gas keeps going up, and the pressure is built up to perhaps 100 pounds higher than had been the normal rate, and the effect of that is to force the fluid level down in the annulus. When the well had been pumping long enough you can have a transient effect, so you have an equilibrium condition, the well pumping steadily at the same rate, and the actual fluid level determination has found that it is perhaps 300

(Testimony of Richard W. French, Jr.)

feet lower in the well; in other words, it is 1300 feet, instead of 1000 feet. Therefore, the thing that makes it go down was the pressure change at the surface, and you say that that much pressure change of 100 pounds forced the fluid down 300 feet, and you therefore get an expression of the density. In other words, you force down 300 feet of fluid for 100 pounds, and so you are then able to calculate the average density of that fluid as it actually exists in the well, whether there is water or gas in the fluid.

The Court: How do you know if you only need 100 pounds?

A. You don't know, so what you do is to set back the pressure regulator to build up a certain pressure. You don't know what it is; whether it should be 100 pounds or not. So you see the result you get, and if it isn't enough, you pinch the valve more.

The Court: What if it is too much?

A. It would force the fluid level down to the pump; that is, the pump is getting gas instead of fluid, and you have a gas lock. Perhaps you have had a vapor lock in [136] your car. On hot days we very often get them. The fluid gets so light that you get in effect gas instead of liquid gasoline. It flashes, and turns to vapor, and you simply stop.

The pressures are determined by comparing these two readings; that is, the data that you get at one level, and at the other level. With that same data you also determine the density of the fluid. Ordi-

(Testimony of Richard W. French, Jr.)

narily the density of the fluid level below the fluid surface, the liquid gaseous mixture, was a constant from the fluid level down throughout its length. That is one of the things we learned.

Mr. Fulwider: Q. Can you tell me where you first heard this fact, that the fluid density was a constant irrespective of the depth, for given running conditions?

A. I believe, without being positive about it, that it was through Mr. Walker's discussion at that time that I heard it.

Q. Do you recall whether or not that theory, when you first heard it, was to you a novel theory, or was it contrary to your preconceived ideas?

A. It was contrary. We had not been led to expect that. We were skeptical.

Q. Were your preconceived ideas those that were generally held by those in the oil industry with whom you were acquainted?

A. It is rather difficult to say. I think it is fair to say it was, because all of us missed the boat about the same amount. I was skeptical about the accuracy of this theory until it was [137] proven to me by Mr. Walker. The fact that the density is constant, or substantially constant, accounts for the curve which is plotted between the depth and the pressure being substantially a straight line. That curve is an expression of density.

Q. I call your attention to Figure 3, of patent Re. 21,383. The straight line appearing on Figure

(Testimony of Richard W. French, Jr.)

3 represents density, does it not, that is, the slope of that line.

A. I would prefer to say it plotted a pressure. This one at the right (Plaintiffs' Exhibit 17) does, certainly.

Q. That is the curve, depth of fluid against casinghead pressure? A. Yes.

Mr. Fulwider: May this graph we have been discussing be marked for identification Plaintiffs' Exhibit No. 17?

Q. State whether or not the fact that the line of Exhibit 17 is straight indicates that the density is constant throughout the depth plotted by that time.

A. A straight line signifies a constant density.

Q. That is correct. If the density were not constant then you would get a curve, I assume?

A. That's right.

Q. Prior to Walker's Depthograph method, which you previously described, your preconceived idea was that the relationship on the line that you would get plotting depth versus casinghead pressure, would have been a curve? [138]

A. In general terms, depth against pressure would have resulted in a curved line.

Q. You expected a curve, and Walker got a straight line? A. Yes.

By the Court: How do you account for the fact that it is the same density?

A. Your Honor, it can only be by the fact that we have proof to calculate this. I can't explain it.

(Testimony of Richard W. French, Jr.)

Q. If it were still, and in a tube, it would not be of the same density?

A. No, if it were still, it would be tremendously different. It would not be coming out a solution. There would be a separation. If you have gas coming out of solution, it complicates this.

Q. You say if it were in a steel tube it would be the same density?

A. If it were in a steel tube, and had a chance to overcome the equilibrium; gas coming out like water in a seltzer bottle.

Q. Suppose you had oil, water and mud?

A. In that case you let the well stand long enough to let all these different densities and the constituents separate themselves, as the laws of gravity say they will if given enough time, and you will have gas on top.

Q. Then you have a curve plotting density?

A. Yes, but a very small curvature of gas. [139]

Q. Suppose you take the stuff out of the oil well and put it in a tube and let it stand, the fluid you have, mud, oil, gas, light oil, heavy oil and so forth, would be the same density?

A. It would be the same density in each fluid. The oil would be of the same density; the mud would be heavier.

Q. Where there is fluid, if you plotted that, you would plot a curve?

A. You would have to segregate the oil; then the water; then the heavier mud, and that would

(Testimony of Richard W. French, Jr.)

make a curve, because there are three different densities.

Q. As I understand your position, it is the opinion of those engaged in the production of oil, at least so far as you personally are concerned, and so far as you know, that the same relationship existed in the fluid in the annular spaces of oil wells? A. Yes.

Q. And you discovered that it did not exist?

A. Yes.

Q. Rather, that it still remained of the same density? A. Substantially.

Q. And the mud, or whatever it was, mixed all the way through?

A. Yes, under pumping conditions, it gives in effect a homogeneous mixture. [140]

Mr. Fulwider: Q. Can you tell me whether or not there are any other sonic methods for determining subsurface pressures?

A. There is another method which gives these pressures without pulling the equipment out of the well, and you are perhaps referring to the one that is known as the Echometer.

I think it is generally lumped together, as the general term is "sonic", that is, determining the fluid level by reflection of the obstruction, whether it is sonic, electric or physical.

Q. Would you say, Mr. French, that the development of the Walker depthograph method satisfied any need then existent in the industry?

A. Yes, undoubtedly.

(Testimony of Richard W. French, Jr.)

Q. And, so far as you know, at the time the Walker depthograph method did satisfy this need there was no other satisfactory method for accomplishing the same purpose in pumping wells, so far as you know? A. Yes.

Cross Examination

By Mr. Graham:

Q. Mr. French, this column of oil in the annular space, or this mixture in the annular space between the tubing and the casing, is a static column, isn't it?

A. The mixture of oil and gas, we don't call it a static column. [141]

Q. What do you call it?

A. Static means the measurement of a column of oil and gas taken with the well shut down; not producing; and built up to full pressure.

Q. The liquid does not move in that column?

A. Do you mean when the well is producing?

Q. When it is a pumping well.

A. It may move slightly in some wells. With complete equilibrium, it does not. We have what are called "column-heads" in the wells.

Q. The liquid at the bottom of that annular column doesn't move to the top, does it?

A. Not during ordinary producing operations.

Q. Suppose that oil had water in that column between the pump and the fluid level, what would happen?

A. In other words, you are assuming water in

(Testimony of Richard W. French, Jr.)

the column above the pump, with the fluid level some place above that?

Q. Yes.

A. So far as I know, unless the mixture were a very unusually thick or viscous and heavy one, the water would ordinarily remain below.

Q. So, when you were talking about the density being constant, you simply limited that to a standing column above the pump? [142]

A. No, I can't say I limited it to that, because in my experience we have found substantial gradients, substantial constant density of gradients extending not only to the pump, but below it.

Q. How would you account for that if the conditions are different in a moving column than in a standing column?

A. In some cases the conditions may be different; on the other hand, you have a change in your annular diameter around the pump; you have so many square inches of annulus below the pump.

Q. What effect does the difference in diameter have on the question of determining density?

A. You are measuring, not a stabilized column; you are determining really a combination of gradients; which we need for those three fluids in motion. They may be stabilized, but the gas is bubbling up all the time.

The Court: So long as you operate the pump?

A. Yes.

Q. Or so long as there is movement?

(Testimony of Richard W. French, Jr.)

A. Yes, you are measuring what affects the little fraction of motion there is in that mixture.

Mr. Graham: Q. Prior to the time that you heard of Mr. Walker's apparatus, and the way he used it, you know they did determine density in flowing wells, don't you?

A. Yes, with pressure gauges.

The Court: After you got the density of the fluid in the [143] annular space, how does that compare with the density of the fluid that comes out of the pump? Is it the same?

A. That is where we got the large surprise; it is much less. The gas has been separated from the oil we measure at the surface, that gas, which was present down in the well; where we have to have the gradient, which we don't measure. When we measured the gas from the oil in the tank or surface it caused a much greater divergence than predicted.

Q. Is there any separation of the gas and the oil in its journey from the bottom of the hole to the surface?

A. It may be a continuous separation.

Q. Depending on the depth of the well?

A. Yes, depending upon the depth of the particular type of oil, the temperature of the oil, and normally the gas in solution in different wells has a different amount as it comes out. The journey of the oil from the formation up into the well is one generally of continuous reduced pressure. You get a lot of gas which bubbles out, in most wells.

(Testimony of Richard W. French, Jr.)

Q. So the oil that comes out of the pump, that is no indication of what the density of the fluid is that enters the pump at the bottom of the well?

A. Exactly.

Mr. Graham: Q. Mr. French, on this chart that has been marked Exhibit No. 17 for identification, you will note that the [144] calculations are of depth of fluid against casing pressures?

A. Yes.

Q. Can you take that chart and determine the density from that chart, by taking the figures that are on that chart?

A. I don't think I can. In all cases we have casing head pressure as the abscissa.

Q. Is it possible to get the density from the data on that chart?

A. I think it is possible in some cases. I don't think it is infallible, because your casing head pressure is on the abscissa rather than the pressure at the fluid surface.

Q. Do you think you can do it?

A. In every case?

Q. In this case right here? A. No.

The Court: Is he supposed to be able to do it?

Mr. Graham: He has been telling us what it is.

A. If you will read back the record, when you asked me if that line was an expression of density, I think I put it in these words: "a plot of depth against fluid pressure is density," and the expression, the density in this chart, which is labeled "casing head pressure", there is an indirect step, your

(Testimony of Richard W. French, Jr.)

Honor. You are taking a jump which includes taking the casing head pressure of this well.

The Court: You don't need your instruments?

[145]

A. Just an ordinary pressure gauge.

Q. You have that all the time?

A. That is right.

Mr. Graham: Referring to Figure 3, of Reissue Patent 21,383, from the data on that chart, you can, however, figure the density, can you not, correctly?

A. I will take a look at that. This is the pressure on fluid surface which implies that you can actually measure the fluid level against depth, so I would say that you can calculate the density.

Redirect Examination

By Mr. Mattingly:

Q. In the measurement, in the plotting of these pressures against the fluid levels, you mean if you measure your gas pressures at the casing head, and plot those against your fluid levels, and that is apparently what has been done on 17, is that correct?

A. This is depth of fluid. I was thinking it was just the depth below the ground. That is right. In depth of fluid, it pertains to measurements made at the same periods these casing pressures were taken, and if there were no difference in the gas correction from the casing pressure gauge, at the fluid surface, it would correspond to this chart.

Q. And the gas correction that you have referred

(Testimony of Richard W. French, Jr.)

to, is that something which is known to engineers who would be [146] attempting to find this information? A. Yes, it is common knowledge.

Q. All that the gas correction amounts to is to add this effect in pressure of the weight of the column of gas?

A. To that measured fluid level.

Q. That is a determinable factor?

A. That is right.

Q. You have in your hands the chart, Exhibit No. 17. You have compared that with this chart?

A. Yes.

Q. And you have referred to Figure 3 of patent Re. 21,383.

A. That is right. On looking at that and seeing the depth of the fluid level, and measuring the exhibit 17—I want to correct that, because I have been thinking of this as just well depth against casing pressure, in my former answers to Mr. Graham, as to density. This is, as I pointed out on 17, depth of fluid measured at corresponding times. This is casing head pressure. Then you are able to calculate the average density. It is substantially the same as figure 3.

Q. That is figure 3 of Patent Re. 21,383?

A. Yes.

Mr. Graham: I will ask counsel if Exhibit 17 is supposed to be a reproduction of this figure 2 appearing in the manual which is in evidence as Exhibit 11C. [147]

(Testimony of Richard W. French, Jr.)

Mr. Mattingly. As far as I am able, with my lack of ability, to draw. That chart should appear immediately preceding Page 52 of the manual. I will stipulate that I made Exhibit 17, as an enlargement merely of that figure, without changing any of the values.

Mr. Graham: That is right. The correction I wish to make, your Honor, is this: the witness has called our attention to it. He read that "depth of fluid," and your Honor will look at the chart in the back, Figure 2, where it says: "Depth to fluid."

Mr. Mattingly: May I make that correction? That was the mistake I made in lettering.

Mr. Graham: I will give the witness an opportunity now to correct it. If that chart, Exhibit 17, read; "Depth to fluid," instead of "depth of fluid," then the answers you gave in your direct examination were incorrect?

A. I am afraid I had better refresh myself on the way I answered, I am afraid I might confuse it.

Mr. Graham: I hand you a copy of the page of the manual, and the manual is Exhibit 11C, which is marked, "Determination of sub-surface pressure," figure 2, and which is like this exhibit 17, with the exception of the depth indication, and I call your attention to the fact that on the chart which is here, the measurement is: "Depth to fluid." Can you determine density with the data that appears on that chart, figure 2? [148]

The Court: Density of what?

Mr. Graham: A column of oil or mixture.

(Testimony of Richard W. French, Jr.)

The Court: The density of a column of fluid in the annular space?

Mr. Graham: That is correct.

A. So long as this well was pumping under substantially stable conditions, in other words, had had time to settle down to a steady pumping rate, which we call equilibrium conditions, this data appears to be ample to make calculations of density.

Q. Your answer now is that you can calculate density from that?

A. Yes.

Q. Will you please do it?

A. I don't have my gas correction material here.

Q. That is the point; I am asking you, with the data that is on that chart, whether you can compute the density?

A. If that is the point, Mr. Graham, this density correction. I was just asked whether it was common knowledge to have a correction, to make the computation, and I said "Yes." If that is the point, you can't do it on this chart, because it isn't on this chart. In other words, there is a correction for the density of the column of gas down the tubing.

The Court: It says "gas column" here.

A. Yes, but a gas column pressure, I presume, your Honor, that is from the surface. But you do not have the [149] surface pressure on this chart. The first casing head pressure is on a level of about 3900 feet.

Mr. Graham: Q. To make the calculation you are talking about, you would have to have the den-

(Testimony of Richard W. French, Jr.)

sity of the gas, and the density of the gas isn't on there?

A. No, but the density of gases, although they vary, in my experience, it is not vital. It doesn't prove the accuracy. In my own case, as a gradient for the field I am working in, it may be .65 or .75.

Q. Then your answer is, with the data on that chart, you could not determine density?

A. The best accurate density, no.

Mr. Fulwider: Q. But you can determine the density by merely applying this gas correction factor that you mentioned? A. Yes.

Q. Which is easily available to you from the known data in the field?

A. Yes, as I say, there is an addition here for the column at the present time, but apparently the attention emphasizes on the exact details for that column correction. It doesn't show exactly what column. I would assume it is a complete difference between two fluid levels.

Q. That curve in Figure 2 of Exhibit 11C may be said to determine density in terms of casing head pressure, could it not, rather than fluid surface pressure? [150]

A. Yes, assuming that the gas correction factors are immaterial.

The Court: Is this supposed to indicate whether the fluid level is reduced by the accumulated pumped or increased gas pressure?

Mr. Graham: The casing pressure is increased.

(Testimony of Richard W. French, Jr.)

Mr. Mattingly: According to the instruction book from which that came, the pumping rate is supposed to be constant.

A. Unless you know the data, it may give wrong results. In other words, you have to know that the well is producing steadily. I was assuming that.

Recross Examination

Mr. Graham: Q. If you follow the procedure in which you said you just used a certain gas density for a field, you would not have the accurate results which you have been emphasizing as necessary for the information that you want by conditions in the well, would you?

A. It is just a question of relative accuracy, Mr. Graham. You would not have the ultimate accuracy that you could get, without this small gas correction, but you would have, in my experience, accuracy suitable for our field work.

Q. If I told you that you would find a variation of 15 per cent would you say that was accurate?

A. No. I would say that could occur in cases, but it is [151] one which we ordinarily don't run into in the field where you are familiar with the gas density.

Q. Is there any value in determining the density in the space between the casing and the tubing, except to determine the sub-surface pressure?

A. There may be, but the only thing I am interested in in this case is the pressure.

Q. So far as you know, that is the only value it

(Testimony of Richard W. French, Jr.)

has to determine sub-surface pressures, is that correct?

A. Well, no, I would say there are other inferences, if you want to state it that way, that can be made from some of this data. In other words, the intermediate steps we have to take to get pressure, teaches us something about that, and the density of the mixture of fluid with gas, coming out of solution, it is possible even to get data of the velocity of gas that might be useful in other places.

Q. That is all a matter of conjecture, those different things you say might be?

A. Yes, that is true.

Q. As a matter of fact, in practical use, the only value of determining density is to aid you in determining the sub-surface pressures, isn't that right?

A. Yes, I would say that is true.

Mr. Graham: I think, your Honor, if that chart 17 is [152] going to be used, unless there is some other purpose for having it that way, that it should be made to agree with Figure 2.

Mr. Mattingly: It is stipulated that it may be corrected to correspond with Figure 2 appearing immediately before Page 52 of Exhibit 11C. [153]

CRANFORD P. WALKER

called as a witness on behalf of the plaintiffs, testified as follows:

My residence address is 2874 Carlaris Road, San Marino. I am the Cranford P. Walker named as inventor in the three patents in suit. I graduated from the Bliss Electrical School at Washington; subsequently taught two years there, and then went to Westinghouse and took the course which they gave for graduate engineers, a two-year course. After finishing that they put me in as a teacher on that course. I taught there one semester, and at the same time attended the Carnegie Institute of Technology.

The Court: You graduated from Carnegie?

A. No, I took special work at Carnegie. This work of teaching in the Westinghouse school for graduate engineers was my particular job. There were four of us teaching on different subjects. One was teaching sales, the other was teaching shop management; the other was teaching designing and testing electrical machinery and apparatus, and that latter position is the one that they gave me. I took quite a number of extension courses, but those are the main ones, plus a large amount of home study. When I finished teaching that course I went on as a regular engineer in the general engineering depart- [154] ment of the Westinghouse Company. My duties were primarily determining the size of materials required for driving all sorts of mechanical equipment, from locomotives on down to water well pumps. After that, I did some sales work in

(Testimony of Cranford P. Walker.)

Los Angeles; I was transferred to the Los Angeles office of the Westinghouse Company, and then went to work for the Llewellyn Iron Works, primarily consisting in the laying out of a steel mill at Torrance. My work was mostly to do with the electrical equipment. It was an all-electric steel mill. I was associated with the Llewellyn Iron Works from early in 1916 until about the middle of 1935. That covered a period in there with the Consolidated Steel Corporation, successors to the Llewellyn Iron Works. After I severed my connections with the Consolidated Steel Corporation in 1935, I was doing general consulting engineering work; mechanical and electrical.

Mr. Mattingly: Will you give the court as briefly as possible the history of the development of the apparatus for determining fluid levels, the methods that you have devised for determining fluid levels, and the method you have devised for obtaining the pressures in the fluid column, densities in fluid columns and production capacities of wells, as described in your three patents which are in suit in this case?

A. In September, 1935, I was told of this method which two Shell engineers, Wyatt and Lehr, had for determining [155] fluid levels in pumping oil wells, and on October 3rd, I went to Ventura to see their equipment demonstrated, and I decided to take on the job of developing suitable equipment for making records of echoes which were received from the fluid level in the well.

(Testimony of Cranford P. Walker.)

The equipment that was demonstrated to me by Lehr and Wyatt at that time was a crude home-made affair, consisting of an ordinary oxygen bottle containing probably 800 cubic inches, in which they stored gas at whatever pressure they had available from some well, at which they obtained the gas. This bottle was connected to a smaller container, about three inches in diameter, probably a foot long, which they filled with gas from the larger container, and the amount of pressure that was put in that container depended upon the depth of the well and the size of the casing. I think I saw it demonstrated from probably 100 pounds up to 500 pounds, in that container. At my request we had that changed over these lengths, to see what happened. They discharged the gas by means of a quick-opening valve, into the well, and the opposite side of the casing from which they were connected was opened to the air. The well had no pressure on it. By means of a stop watch, from the start, at the time the gas was discharged into the well, they held their hand opposite the opening, and as soon as they felt a puff, and heard it coming back they snapped the watch, [156] and from then on they told you roughly what the fluid level was; what the distance of the fluid level was, and just what velocity that was. It was primarily a demonstration of the equipment that they had.

The equipment they had consisted of a bottle of stored gas, a chamber into which they would let a

(Testimony of Cranford P. Walker.)

quantity of that gas, a quick-opening valve to let the gas go into the well, a stop watch and the hand of the person who held it over the opening in the casinghead, to attempt to feel the impulse as it came back.

Q. Is that the apparatus which is illustrated in Figure 1 of the Lehr and Wyatt patent, which has been referred to in this case?

A. Yes. The equipment which that demonstrates was substantially the same as that shown in Figure 1 of the Wyatt and Lehr patent 2,047,794.

[Printer's Note: Plaintiffs' Exhibit No. 18 is set out in full in the Book of Exhibits.]

Q. At the time of this demonstration to you on October 3, 1935 did Lehr and Wyatt demonstrate to you any apparatus in accordance with Figure 2 of the Lehr and Wyatt patent that we have just referred to?

A. No. There was no recording apparatus connecting the apparatus which they demonstrated to me.

Q. When you say that you decided to take on the job of developing—I believe you were going to take on the job of developing apparatus for the practice of the Lehr and Wyatt [157] method; is that correct? A. Yes, sir.

Q. What did you do as a result of that decision?

A. I think for the balance of October, I spent practically all of that time investigating the various devices on the market, microphones, amplifiers

(Testimony of Cranford P. Walker.)

and electric recording devices, but was unable to find any that I considered of sufficient speed as a recorder and of the proper type as an amplifier. I had had considerable experience with recorders such as shown in Figure 2 of the Wyatt and Lehr patent, both at Westinghouse, primarily in connection with the test of high speed elevators, and here in Los Angeles I was in charge of the Electrical and Mechanical Department of the Llewellyn Iron Works where we developed the variable voltage elevator on the Pacific Coast. As I said, we did a large amount of testing of those elevators while operating at high speed, and those elevators require very fast instruments for recording the performance of the voltage, amperage and acceleration; but at that time I was not able to find any that had sufficient speed to keep up with the changes in those circuits, the changes of current and voltage and acceleration, except an electric oscillograph. So I had the same experience a little later when I was trying to find something to record the echoes and which would have speed enough to record them properly, according to my ideas.

Q. Did you attempt to assemble any apparatus with the Lehr and Wyatt gas bottle and gas chamber and quick-opening [158] valve for the purpose of making a record of the echoes which were received back from the well?

A. Yes. In November I assembled two different types of microphones, an amplifier and an oscillograph, and experimented with those on a shallow

(Testimony of Cranford P. Walker.)

well at Signal Hill. That was the Cosboom No. 1 well. On these tests I used a carbon microphone known as a type A, made by the Universal Microphone Co. of Inglewood; also a dynamic type of microphone, which is a microphone with a moving coil attached to the diaphragm, which coil moves in a magnetic field as the diaphragm is actuated by pressure waves or sound waves. The recording instrument was a Westinghouse Electric oscillograph, which makes a record on a photographic film which can be removed from the oscillograph.

Q. Do you have any copies of the films or records which were made on that well at Signal Hill with that apparatus you have just described?

A. Yes. I was able to find two of them.

Q. Mr. Walker, just before the end of the morning session I asked you whether you had any charts which had been produced by the apparatus which you assembled together, including the electrical microphone and the electrical oscillograph, which you used in an attempt to practice the method of the Lehr and Wyatt patent. Do you have these charts?

A. Yes. The one marked Film No. 2 of November 19th, 1935, [159] was made with a carbon microphone and an amplifier and an oscillograph, on well called Cosboom No. 1 for the Shell Oil Company, that I referred to in my testimony this morning.

Mr. Mattingly: At this time I offer in evidence chart just produced by the witness as Plaintiffs' Exhibit— —

(Testimony of Cranford P. Walker.)

The Court: Plaintiffs' Exhibit 19. These are reproductions of the original chart; is that right?

Mr. Mattingly: That is correct, your Honor.

The Court: It is stipulated that the copies may be used.

[Printer's Note: Plaintiffs' Exhibit No. 19 is set out in full in the Book of Exhibits.]

Mr. Mattingly: Q. You have produced another record chart. Will you identify that, please?

A. That original film was marked Film No. 1, November 20, 1935, and was made by using a dynamic type of microphone on Cosboom No. 1 on Signal Hill, a dynamic type of microphone and the same amplifier, which is known as a cardiac—that is, an amplifier that would respond to low frequencies for measuring heart beats and pulse action.

Mr. Mattingly: At this time I offer in evidence the record chart just produced by the witness, dated November 20, 1935, as Plaintiffs' Exhibit No. 20.

[Printer's Note: Plaintiffs' Exhibit No. 20 is set out in full in the Book of Exhibits.]

The Court: Where is the beginning and the ending?

The Witness: The beginning is to the left.

The Court: I see. There are three exposures here.

The Witness: Three exposures, yes, and those indicate [160] something that was coming from the well. The complete record is supposed to be on the left-hand end, but the shutter was closed and we

(Testimony of Cranford P. Walker.)

didn't get the start on that; just got the other three there; just got the echoes that came back.

The Court: Exposure No. 1 was a blank?

A. Yes.

The Court: So 2, 3 and 4 on No. 19 are exposures produced immediately after one another; is that right?

A. Yes, in succession as they are numbered.

By Mr. Mattingly: Q. Referring to Plaintiffs' Exhibit 19, will you explain what is shown on that chart with reference to the injection of the gas slug into the well and any echoes which may have returned from the portion of the wall on which you were testing?

A. The record of the injection of the gas slug is not shown there. As I said before, the shutter happened to be closed and we missed that. But the following exposures, No. 2 and 3 and No. 4 were the return echoes. That is what we were trying to pick up, were the return echoes. We were not particularly interested in the record of the release of the gas.

The Court: You have one marked here No. 4, of Exhibit 19, "gas released."

A. That is right, your Honor. That No. 4 is the release of the gas. The first splash on that record there is gas released [161]

Mr. Graham: May I ask which end he is starting at, the left or right?

The Court: He is starting at the left, but he said that the films here did not indicate any release of the gas. No. 2 and 3 do not indicate that?

(Testimony of Cranford P. Walker.)

A. 2 and 3 do not indicate the release of the gas. We missed it on the first one, so on No. 4 we got the release of the gas.

The Court: That is, you did it over again?

A. Yes. 2 and 3 are the return echoes, and No. 4 when we released the gas. The first disturbance shown is when the valve retaining the gas in that bottle was opened and was discharged into the casing of the well. The next major disturbances on there is when the protecting valve, which is immediately ahead of our microphone, to keep from injuring the microphone when the gas is discharged into the well—that second disturbance is when that protecting valve was opened to make the diaphragm microphone sensitive to pick up the return echoes.

That is the second disturbance.

The Court: That is the fourth disturbance on this film, the way I count.

A. I referred to it as the second major disturbance, your Honor. It is the second disturbance.

The Court: No. 1, then the next little jiggle is No. 2, [162] and the next is 3 and the next is 4.

Mr. Mattingly: No. 2 would be the major disturbance that the witness has just been referring to.

The Court: It says there "Valve to mike opened." Now, start at the beginning, the "gas released."

A. "Gas released" is now marked No. 1.

The Court: Now, what is No. 2.

A. I don't know what No. 2 is. Neither do I know what No. 3 is. We frequently had gas dis-

(Testimony of Cranford P. Walker.)

turbances which came from the bottom of the hole, which are interspersed anywhere along here. So that is probably a burst of gas from the fluid that caused this disturbance.

By Mr. Mattingly:

Q. Do any of the markings or wiggles on that line indicate the reflections from obstructions in the well, as far as you can tell from that record?

A. Well, I think that on exposure No. 2 there are two disturbances, and we know those are repeated on exposure No. 3. I concluded that that came from something in the well, but I don't know what they were from.

Q. You could not identify it as being a tube collar or tube catcher or fluid level?

A. No.

Q. Or any particular kind of an obstruction in that well? A. No.

The Court: See if I understand what he did here. You introduced that pressure impulse? [163]

A. That is right.

The Court: And the first exposure was closed?

A. That is correct.

The Court: How did you get No. 2 and No. 3, just leave the camera on, or whatever you call it, the oscillograph?

A. Those blueprints——

The Court: Well, these were reverberations; is that right?

A. Those blueprints represent the length of a

(Testimony of Cranford P. Walker.)

standard kodak film, and we wanted to get as many of the significant points or reflections on it as we could. So we didn't let it run continuously from the time the wave started down until it came back. And on exposures No. 2 and No. 3 we started the film just in time to catch the return echoes.

The Court: Only the return echoes?

A. The return echoes.

The Court: You didn't get the——

A. We didn't get the start.

The Court: Well, that's all you ever get, is the return echo, isn't it?

A. Well, we record the start when it starts down, as we did on this exposure No. 4. Then we start the film before we reach the gas. We ran out of film before the echoes came back on that one.

The Court: On No. 4? A. Yes. [164]

The Court: All these, clear to the end of No. 4, are just the sounds going down or the sounds bouncing back?

A. That is No. 1.

The Court: No. 4.

A. The disturbance No. 1 on exposure No. 4 was when this gas was discharged into the oil well. Then very soon thereafter we opened the valve to expose the microphone—We had a by-pass around the microphone, which permitted us to make a record of this release of the gas—a restricted by-pass. Then we immediately opened the valve, opened up the well right into the microphone, which is shown as disturbance No. 4 on exposure No. 4. Up to that

(Testimony of Cranford P. Walker.)

time there was a quarter inch pipe with a needle valve in it, which permitted the disturbances to come from the well and be recorded on the film.

The Court: And between 1 and 4, as I understand are reverberations from the well? These are just the sounds from the introduction of the impulse?

A. Well, those disturbances could be from the well, and most likely were.

The Court: Where did you measure the depth of the fluid?

A. That isn't recorded. We ran out of film before those echoes came back. We had really been trying to record those echoes on exposures 2 and 3. We didn't start the camera until the time we expected those echoes to reach the surface, or just a little ahead of that time. [165]

The Court: The non exposure No. 2, this first disturbance, the one to the left——

A. That is an echo from the well.

The Court: That is an echo from the fluid level?

A. Well, I don't think it is the fluid level. It is something in the well.

The Court: What is the next one?

A. That was another obstruction in the well. I imagine the first one was a catcher, probably, and the second was a liner top.

The Court: All right.

A. The fluid level I don't think is shown.

The Court: You don't think the fluid level is shown?

A. No.

(Testimony of Cranford P. Walker.)

Mr. Mattingly: Q. To get the record straight, on the left-hand end of this chart, Exhibit 19, is a piece of film which was not exposed because the shutter of the camera was not open during the time of making that chart; is that correct?

A. That is correct.

Q. Then the next one, marked exposure No. 2, is the part of the film which was exposed but which was started to be exposed after your second impulse had been introduced into the well?

A. Yes.

Q. And exposure No. 3 is the portion of the film which was exposed during a third test, and again this film was started after the third impulse had been injected into the well? [166]

A. Yes.

Q. And exposure No. 4 is that part of the film on which was recorded a complete operation, and in that case the film was started just before the fourth impulse was injected into the well?

A. Yes, that is correct, except it isn't a complete operation. Take film No. 2, for instance, and just tack it onto the end of—if exposure No. 2 were placed at the end of No. 4 you would have a complete record, the start of the impulse, as well as the return echoes from that impulse. The camera held such a small quantity of film that we wanted to get as many reflections as we could.

The Court: Is that the original film there?

A. Yes.

(Testimony of Cranford P. Walker.)

The Court: Let me see it. Will it injure it?

A. No. (Handing film to the Court.)

The Court. Then you attached these together?

A. No, they are not attached together, your Honor. That is a standard length. I believe that is a six exposure Eastman film. Those markings are just where we stopped the camera.

Mr. Mattingly: Q. Mr. Walker, would you explain to the Court what is shown on the record strip, Plaintiffs' Exhibit 20?

A. That is similar to Exhibit 19, except I was using a dynamic type microphone, the same amplifier and same recorder, that is an electric oscillator, as I used for making the record [167] known as Exhibit No. 19. In that film it looks like something happened. We missed the first shot, because there is quite a blank on the end of it on the left. And the first record on that film is not marked, but it looks like the echoes of something.

Q. Would you put a bracket about those parts that you are just referring to, and mark that "A"? Does that record show any complete record showing the putting of the impulse into the well and the recording of echoes back from the well?

A. It shows one or the other, but I don't see which it is.

Q. I mean anywhere on that record strip, which you have just produced as Exhibit 20, is there shown any complete recording of the firing of the shot and the return back of a series of echoes from the well?

(Testimony of Cranford P. Walker.)

A. Yes. The exposure on the right-hand end, which is about the right-hand half of the record, is a complete——

The Court: Well, let's identify that some way. Mark on there with a bracket and call it—that is exposure No. 3 on this film, isn't it?

A. It appears to be.

The Court: All right. Mark that exposure No. 3 on Exhibit 20. That is your first complete record?

A. That is the first complete record.

Mr. Mattingly: Q. On that record will you identify the recordings which indicate the injection of the impulses into the well? [168]

A. The first disturbance, I would say, is the injection of gas into the well, which we will mark No. 1. The next disturbance, which is of a longer duration, is where the protecting valve was opened; and I will mark it No. 2. There is a disturbance following that immediately. I don't know what that is. We can identify it as No. 3. Then there is a tiny disturbance half way down to the next major disturbance, which is probably a gas disturbance or it may have been something in the well. Then we come to a major disturbance which lasted for about almost two inches on this record. We can number that No. 5. And then about three inches from where that started there is another disturbance——

The Court: What is No. 5?

A. I don't know what that is.

(Testimony of Cranford P. Walker.)

The Court: Could that be the fluid level?

A. No, that is not the fluid level. That most likely is gas breaking through the fluid surface. As far as the actual records go, I don't believe there is anything shown at that point. And about three inches from that No. 5 large disturbance is a small disturbance there. For the purpose of identification we will call that No. 6.

Mr. Mattingly: Q. Do you know what that disturbance was?

A. No. That is an extraneous disturbance that we don't know why it occurred. There is another little disturbance [169] there. I suppose we should call that No. 7.

The Court: Let's see which one you are calling 7.

A. That is about an inch from No. 6, your Honor. About an inch. The light spot was thrown so far it didn't record there for a fraction of a second. The next disturbance is about three inches from No. 7, and lasted for about half an inch on the record. I am numbering that No. 8.

Mr. Mattingly: Q. Do you know what that disturbance was caused by?

A. No, I don't know what that came from. Then there is another little disturbance a little over an inch from No. 8. We will call it No. 9. And about three-quarters of an inch farther aong is another disturbance; No. 10; and those, I think, are from a catcher or liner top, but they were not distinct enough to be sure just what they are from.

(Testimony of Cranford P. Walker.)

Q. Is there any reflection from the fluid level shown on this chart, No. 20?

A. I don't think so.

Q. Could you, from the records which were made at that time and copies of which you have produced here, have determined the location of the tube catcher and the liner top with respect to the location of the fluid level?

A. W were not able to locate any that we were sure of.

Q. Do you have any other records that were made with an electrical oscillograph and microphone equipment that you [170] testified about this morning? A. No.

Q. What did you do after you made the two records, Exhibits 19 and 20, with respect to attempting to assemble or use apparatus for the purpose of making these fluid level determinations?

A. The result of those tests was so unsatisfactory that I immediately began the construction of an experimental—what I will refer to as a diaphragm type of receiver, which was a diaphragm which the pressure waves would impinge. Attached to that diaphragm and actuated by it we placed a tiny mirror, which took the place of the mirror in the electric oscillograph, which was electrically operated. This mirror was operated mechanically instead of electrically. I used practically the same optical system as that in the oscillograph, a tiny light shining on the mirror and light reflected from the mirror through an optical system onto the photo field.

(Testimony of Cranford P. Walker.)

On December 12, 1935, we had that equipmer finished and took it to this same well, that is, Co boom No. 1 at Signal Hill, and tried it out. I hav here film No. 2, made with that equipment at Co boom No. 1 well, of the Shell Oil Company on Sig nal Hill, on December 12, 1935.

Mr. Mattingly: I offer the chart just produce as Plaintiffs' Exhibit 21. Will you explain wha is recorded on [171] this record, Exhibit 21, whic you have just produced?

[Printer's Note: Plaintiffs' Exhibit No. 2 is set out in full in the Book of Exhibits.]

A. The first break in the light line on that cha is the release of the gas from what we call the im pulse chamber. That is where we stored our ga preliminary to discharging it into the well casing It is marked "Gas Released". The next break i the light line is where the valve protecting th diaphragm was opened, exposing the instrumer through the two-inch pipe to the well. Previous t that time the diaphragm had been exposed to th well through a quarter-inch pipe with a needle valv in it. And about four inches farther along fro that break in the line there is a disturbance, whic isn't identified. Shall I identify it?

The Court: Well, you had better start with "Ga released" as one; "Valve to recorder opened", a No. 2; the next disturbance as No. 3, and so on.

A. No. 3 is the one that is about three-quarter of an inch long.

(Testimony of Cranford P. Walker.)

The Court: The big one? A. Yes.

Mr. Mattingly: Q. Do you know what that disturbance was caused by?

A. No. Then the next complete break in the line is a little over three inches from the disturbance No. 3, and it is marked "Echo from obstruction". I will mark it No. 4. The [172] next break in the line is marked "Main echo". I will mark that No. 5. At the time those were made I didn't know what that "Echo from obstruction" or the "Main echo" was from. But I think when we got the well records a few months later, that "Main echo" was the liner top. The Shell Oil Company maintains those well records. Those records that are kept by the oil companies show the location of the liner top, the pump, and try to keep a record of the location of the tube catcher, but they can't always depend upon it because the field men don't always turn it in accurately, and sometimes don't turn in the change at all.

Q. How do they get those records?

A. The men who pull the tubing out of the wells—perhaps I should start on the casing first. When a well is drilled they keep a complete log of every foot of pipe that goes into the hole, and from that log any change in the size of the pipe can be determined. And the liner, of course, is usually smaller than the pipe above it, because it is installed through the pipe up above it and is usually perforated and is what they call a screen

(Testimony of Cranford P. Walker.)

pipe. Then when they run the tubing in they keep a tally sheet of the tubing that is run into the well, the number of stands, the number or joints per stand, and location of the catchers and the total tubing in the well, which, of course, gives them the location of the pump.

The Court: That "Main echo" was a tube catcher, you say. [173]

A. The "Main echo", I think on that one, is the top of the liner, which is smaller and constitutes a restriction in the well, which would produce a reflection.

The Court: Well, that liner is where the size of the well is reduced, isn't it?

A. Yes. And any change in the size, either an increase or a decrease, causes a reflection and is recorded.

The Court: Does that show a reflection from the fluid?

A. I don't believe the fluid reflection shows on that one.

The Court: That isn't the complete record, then, is it?

A. There is nothing shown farther on down. The fluid was down inside this liner, some place, and it isn't always easy to obtain reflections, from the fluid level when so much of the energy is reflected back from the top of the liner; besides, so much of that energy goes out through the perforations and is lost and never comes back; so it is

(Testimony of Cranford P. Walker.)

difficult to get reflection from the fluid when it is down inside of the liner.

Mr. Mattingly: Q. Do you know whether there was tubing in that well at the time you made that test, Exhibit No. 21?

A. There was tubing in that well and it was producing at the time of the test. The pump was operating during the time we were making the test.

Q. Could you, from an inspection of that record, Exhibit 21, determine how many lengths of tubing there are in that well? [174] A. No.

Q. Will you explain to the Court why it is that when you were trying to select this equipment that you selected and tried out a carbon type of microphone and a dynamic type of microphone and why you didn't select perhaps another type of microphone?

A. There did not appear to be any other type of microphone that would meet the requirements at all. I wanted a microphone that would show the magnitude of the reflection, the duration of the reflection and the direction, so we could interpret the reflection we got. I tried to get a reproduction of the microphone which would produce all the irregularities inside of the well-casing, in the annulus.

Q. Did you attempt to use the hot wire microphone?

A. No, I did not think it possessed the proper characteristics. It had no directional properties.

(Testimony of Cranford P. Walker.)

A crystal type of microphone appeared to be about the best type, but it does not function when it gets above 130° F. In the San Joaquin Valley, if the microphone is placed in a black pipe, the pipe sometimes gets up to 150° so the microphone would be useless, the crystal type would be rendered useless before it got up to that high temperature. The crystal microphone has directional properties, because it is the same as the carbon. The dynamic microphone hasn't any proper properties and is not suitable for low frequencies.

Q. Explain what you mean by a directional properties [175] in a microphone.

A. One type of microphone, when an impulse encounters a constriction in the pipe, a pressure wave is reflected and the microphone should show a recording device moving in one direction. When it strikes a perforation where the hole gets larger, we wanted something to show the fact that it had struck an enlargement, and that light beam or record element would move in an opposite direction.

Q. Does a hot wire microphone have the property of distinguishing between a constriction in the well and an enlargement in the well?

A. It does not.

By the Court: Did you find a microphone that when it hit one type of construction would do one way, and if it hit another type would record on the other side? As I understood your testimony that was what you were looking for.

(Testimony of Cranford P. Walker.)

A. That was what I was looking for. I did not find a satisfactory one. The carbon microphone was the nearest we could come to it, but it wasn't practical, because when exposed to wet gas the crystal has an affinity to wet gas and it would put it out of commission. I don't know anything yet that is satisfactory in the way of an electric microphone.

Q. A hot wire is not? A. It is not.

Q. Did not the apparatus work here the other day? [176]

A. It will show single reflections all right. In Kansas wells are quite simple; they run about 3300 feet deep on the average, with nothing to interfere but the fluid level, so the hot wire microphone worked all right under conditions of that kind. And the daddy of that outfit got confidential, one time, and admitted that his hot wire was not suitable for California conditions.

Mr. Mattingly: Q. By the directional characteristics of that microphone, in your explanation to the Court, did I understand you mean, in making a graph with a non-directional microphone, such as a hot wire microphone, the record, for example, of the tubing catcher would show part of that reflection extending in two directions; for example toward the right, viewed on the drawing of patent 2,156,519 and then, if the wave encountered an enlargement, such as a perforation or hole in the casing of the well, then it would also show a break in the line, the start of which also would be to the right.

(Testimony of Cranford P. Walker.)

A. That is true of the hot wire microphone, and any other non-directional microphone.

Q. Then these two types of obstructions, one of which constricts, and the other an enlargement; would be registered by the hot wire microphone as though they were both constrictions, is that right?

A. That is right, under California conditions, and [177] in South Texas, I believe, but at any rate it is true in California. We have a large number of reflections from many of the wells, and if we are not able to identify those by the direction in which they are recorded, we are just lost in a maze; we don't know which is the fluid level.

The Court: A hot wire microphone would record those obstructions in the well. What about tubing collars? Does the hot wire microphone record those regularly? A. I understand it does.

Q. What about your microphone?

A. It records them frequently and regularly.

Q. And to the right and left—I say right and left; I am looking at this vertically. So that the tubing collar markings are on a theoretical center line, either on one side of the line of these variations in the line or on the other side?

A. That is correct, although that is not so very important in the recordings of tubing collars. Then when you come down to some other obstruction in the well, say when you hit a liner, for instance, you get one kind of a marking on this record, and when you hit some other kind of an obstruction or constriction, the deflection is in the same direction

(Testimony of Cranford P. Walker.)

as when a wave encounters any constriction in the well. A narrowing down or obstacle, or partial obstacle, reflects a wave, which is a pressure wave, but if it runs into an enlargement of the path it is traveling, the [178] annular space, it creates a slight vacuum called a rarefaction. Tubing collars are constrictions of the annular space.

Q. Then where do you fi d the enlargement?

A. The well bore at th. bottom is usually larger than the screen pipe that is set into the bore, and there is usually a section of that pipe that is not perforated, from 10 to a hundred feet or more, between the liner top, until you get down to the producing horizon, where the perforations start; that is smaller than the bore.

The Court: Smaller than the well, your hole in the ground?

A. It is small, so the wave cannot travel in the bore. It is confined to the pipe. After it passes the liner top, the area of the annulus, frequently, roughly is half of the area of the annulus bore to that of the liner, but the space where the bore is the same all the way down and is large enough to accommodate the large pipe above the top of the liner, when it strikes the constriction, the pressure wave is reflected back, but as soon as it reaches a point where the perforations begin it is again able to get outside of the liner, and travel in the space behind the liner or a cross section area.

The Court: I think you had better take a piece of chalk, and make a diagram for me. You have

(Testimony of Cranford P. Walker.)

marked "bore". Normally that is outside of the well-casing?

A. In other words, ordinarily there is no casing. You have [179] no hole that is of uniform diameter all the way down. They sometimes change bits, and bore a smaller hole, but when they reach the top of the oil sand they run the pipe in, which is called the water string. I will mark it "casing"; and that is cemented at the top of the oil sand and then they run in a perforated pipe, called the "liner".

Q. That goes all the way through, however, doesn't it?

A. No, it just goes to the top of the oil sand. There is no particular object in having it all the way up. The reason for that is, so that you can cement off the hole and prevent surface water from coming down and getting into the oil sand, so that pipe of a smaller diameter, or a combination which is frequently used on the water string is a casing of 8 and 5/8ths, with a liner of 6 5/8ths, and a 2½ inch tubing changes the area of that annular space. It is about 40 inches across, this section of the area here, and it drops down about 21 inches here, so it cuts the annual space in half. So you get quite a reflection of the wave out of the liner, but when the wave hits the point where the perforations occur, it has the area between the tubing and the liner and the well bore, which brings it back to 40 square inches again.

Q. The fluid level is above the top of the liner?

A. Just the one reflection. When that wave hits

(Testimony of Cranford P. Walker.)

an enlargement it reflects a wave rarefaction, and that should [180] record in the opposite direction from which this pressure wave record would occur when you hit the top of the liner. So it should be recorded, to know it is not a fluid level.

Q. You get the same kind of a reflection from the top of your liner that you get from your tubing collar?

A. Yes, or the fluid level if it were there. Then when we hit these perforations, we got back in the larger area, and a wave, sometimes quite a strong one, of rarefaction or partial vacuum, is reflected to the top,—which gives a different kind,—in the opposite direction on the chart.

Q. And the microphone is the thing that selects it? A. That is correct.

Q. Have you got any of these rarefaction waves on your chart? You have a chart here which is exhibit No. 4.

A. There are none shown in that chart.

Mr. Mattingly: Q. Mr. Walker, will you draw us a line indicating on the chart how it would record the pressure wave from the constriction in the well.

The Court: Just draw it, and put a tubing collar up there in your tubing.

A. I will start this off. That is where the discharge is, really. When you hit the tubing collar you get a slight reflection.

The Court: Only one to the right. Do you only get one?

(Testimony of Cranford P. Walker.)

A. I am drawing it to correspond with this picture.

Q. I understand, but I am asking you if when you [181] hit the tubing collar you only get the one?

A. One to the right. They are so close together that they almost overlap. It is just a continuous train of waves and sometimes they are just peaks. When you strike this liner top you get quite a large reflection. It shows the fluid level down inside of the liner, but almost at the pump, so when we hit the fluid level, and you have a shale break, or something caves in behind the liner at that point, when you hit that, you get another of these.

Q. In the same direction as the tubing collar?

A. In the same direction. When we hit the fluid level you get another one, so if these are not, all of them, in their proper direction you can get entirely lost in trying to interpret it.

Q. And these that are on the drawing or patent 2,156,519, you will see C and D—in Fig. 3, goes first to the right, and then across the line to the left.

A. Sometimes, if the instrument is not adjusted properly, it will swing some little distance. That is just an overshooting of the instrument, but it is the longer arm of the two that gives the information we seek.

Q. What kind of a wave do you call this?

A. A rarefaction.

(Testimony of Cranford P. Walker.)

Q. These are pressure waves and the others rarefaction waves?

A. Yes. A rarefaction wave is a vacuum, or a partial vacuum. If you place two pieces of cardboard together, and suddenly [132] separate them, a partial vacuum is created between those two pieces of paper. That is the zone rarefaction, as compared with air pressure.

Q. In other words, it blows until you get down to where the other sucks.

A. It pushes until it gets down there to the larger space, and it causes a suction, causes a rarefaction.

Q. In other words, the sound travels by these holes, and creates suction?

A. No, it runs into the larger space, where it travels more easily; there is less resistance, where it tends to jump ahead a little bit.

Mr. Mattingly: Q. I made a copy of the drawing which appears on the board, which has just been made by the witness.

The Court: Will counsel stipulate that it is a reasonable facsimile?

Mr. Graham: Yes, your Honor.

Mr. Mattingly: I offer that in evidence as Plaintiffs' Exhibit No. 22.

[Printer's Note: Plaintiffs' Exhibit No. 22 is set out in full in the Book of Exhibits.]

Mr. Graham: It is merely illustrative of the witness' testimony.

(Testimony of Cranford P. Walker.)

Mr. Mattingly: At this time, your Honor, I believe we have the Exhibit No. 17 identified which I will at this time offer in evidence as Plaintiffs' Exhibit No. 17.

The Court: Has that been corrected? [183]

Mr. Mattingly: Yes, it has been. I offer that in evidence as Plaintiffs' Exhibit No. 17.

(Exhibit 17 is not in this record. It is the same as Fig. 2 of Exhibit 11C.)

The Court: It may be admitted. Before we go on to the next thing, let us go back to "rarefaction". What kind of a microphone is it that you say records these different waves in a different manner?

A. About the only one would be a carbon microphone or the crystal microphone, neither of which is suitable for that type of service.

Q. Is that what you use now in your equipment?

A. No, we use a diaphragm which actuates a mirror direct; there is nothing electrical.

Q. Mark "22" on the blackboard then. Exhibit 22 is a diagram explanatory of what you desired, is that right. A. That is correct.

Q. How did you know what you desired when you did not know anything about these pressures in the back of the well? In back of the perforations, etc.

A. It was just a part of my training. I wanted to have everything as near exact as possible, and to give an exact reproduction of whatever was in there.

(Testimony of Cranford P. Walker.)

Q. Does the present diaphragm and mirror arrangement respond [184] like the microphone that would record these different waves? A. Yes.

Q. It gives the same differences then?

A. The same differences, yes.

Q. A hot wire microphone will not do that?

A. Not that I have any knowledge of.

Q. All right. Is this a matter of common knowledge, or is this a matter upon which you claim invention or discovery? What is your position?

Mr. Mattingly: That is not a point which is really in issue in this case, your Honor. That evidence was brought out merely to show——

The Court: It is one that goes to the method?

Mr. Mattingly: Not exactly. It was brought out primarily for the purpose of showing what was available at the time Mr. Walker entered this field for development; what was available to him in his apparatus.

Q. The point is that this apparatus was available to him.

Mr. Mattingly: That is correct. Immediately following the period in which you employed the apparatus and made Plaintiffs' Exhibit No. 21, will you state what you did, Mr. Walker?

A. I immediately began designing a commercial unit which would work like the temporary test unit with which the record, Exhibit No. 21, was made. I completed the commercial unit I [185] started at that time. It was first used on March 6th, 1936,

(Testimony of Cranford P. Walker.)

in testing a well of the Shell Oil Co. in the Signal Hill field, and the particular well was Alimitos No. 39.

Q. Will you please explain what the type of apparatus was that you completed as a commercial apparatus and state whether or not that apparatus is diagrammatically illustrated in the drawing of patent 2,156,519.

A. That is, with the exception of the adjustable nipple shown as No. 19 on that exhibit. The apparatus which I used on March 6, 1936, also included the part which has been referred to here as the calibrating tube and which is identified by the characters 53 to 67 on the drawing of patent 2,156,519. That was part of the equipment that we deemed very desirable to make. Mr. Wyatt had told us that although this patent teaches the method of determining the velocity at which sound wave travels in the gas in the well, that that was not at all dependable. That method involves taking a sample of the gas, measuring its velocity, and from the gravity determining the theoretical velocity at which the wave would travel in the gas. They had to make a temperature correction; had to assume a temperature of this gas column, so he said that they frequently got fluid levels way below the bottom of the well, and he strongly recommended devising something that would give more accurate results than timing the velocity from which to determine the fluid level; and the design of that equipment was started about the same time [186]

(Testimony of Cranford P. Walker.)

as I designed the receiving and recording apparatus shown in that exhibit were started.

The Court: The echoes or sound that you recorded and counted—what was it?

A. It is a form of sound wave. A sound wave is a pressure wave.

Mr. Mattingly: I believe you said that you commercially used this machine to make a test about March 6, 1936. Did you keep a copy of the records that you made at that time?

A. Yes; I found one.

Q. I show you a copy of a chart which was marked during the taking of the depositions as Defendant's Exhibit D-4, and ask you if that is the record that you refer to?

A. That is the record.

Mr. Mattingly: I offer the record just identified by the witness as Plaintiffs' Exhibit No. 23.

[Printer's Note: Plaintiffs' Exhibit No. 23 is set out in full in the Book of Exhibits.]

Mr. Walker, will you look at the chart, Exhibit No. 23, and explain briefly to the court what is represented on that chart?

A. About two inches from the left-hand end of the chart, the dark black line is broken, and a thin line extends on toward the top of the chart. That is the point where the gas was discharged into the well to create the impulse. That is point No. 1. It is the indication of the pressure impulse. It has [187] quite a long indication, from the time

(Testimony of Cranford P. Walker.)

it got back onto the track. The protecting valve was open. It is in front of the diaphragm, to prevent it from being injured by the shock of the pressure impulse.

Q. That valve is No. 21, on the drawing of patent 2,156,519, will you continue, Mr. Walker?

A. That light beam gets back onto the center of the chart, or near the center at 2. That is about nine spaces on the time scale from the beginning of the record; since there was no tubing in that well, I don't know just what these oscillations were due to, and there is nothing of significance until we get down within about 7 inches of the end of the chart; there is a deflection which I mark 3 toward the top of the chart, or toward the time scale. Those are one-tenth of a second marks, the small ones; the major marks on the time scale, the major diamonds are one second apart. Then there doesn't appear to be anything else until you get close to the end of the chart, where the echo from the fluid level is recorded, which I mark 4. It is actually 7.26 seconds from No. 1 point.

Q. What did you do with this apparatus, this commercial apparatus, with which you made chart, Exhibit No. 23, subsequent to this first commercial test on March 6, 1936?

A. On March 7th we made another test, two or three of them, I suppose, but I know we made one more test, and that was [188] on a well belonging to the Shell Oil Company known as Nesa No. 1 on

(Testimony of Cranford P. Walker.)

Signal Hill. Incidentally, this Exhibit 23 was a Shell Oil Company well also, Alamitos No. 39. I have a copy of the record I made at Nesa No. 1 well.

Mr. Mattingly: I offer in evidence the record which has just been identified by the witness as being of the Nesa No. 1 well, as Plaintiffs' Exhibit No. 24, and that Exhibit No. 24 is the same as Exhibit D-8 attached to the Walker depositions.

[Printer's Note: Plaintiffs' Exhibit No. 24 is set out in full in the Book of Exhibits.]

A. The date which was written on that chart is not correct. It was inadvertently put May 7th, when it really was March 7th.

Q. Do you know who put the date marks on the chart you have referred to, on Exhibit 24?

A. I put it on there.

Q. The May 7th date was a mistake that you made?

A. Yes, the two months being similar in spelling, I made the mistake.

Q. Will you explain briefly what is shown on the chart you have just produced, Exhibit No. 24, and mark the various points to which you refer?

A. About three-quarters of an inch from the left-hand end of that chart——

The Court: That is the one that does not have the time chart on it, does it?

A. No, there is no time scale on that. There is a break [189] in the heavy black line, and the thin line extending toward the top, and that is where the

(Testimony of Cranford P. Walker.)

gas was discharged into the well to create the pressure impulse No. 1. The protecting valve on that sheet is not open until we get down about six inches from No. 1, and that point is marked No. 2. I presume that was where it was opened, because it is so quiet until we get to that point. Then going on until we get to within about one inch of the large reflection, near the right-hand end of the chart, there is a small deflection of the light beam toward the bottom of the chart. That would be a rarefaction, marked No. 3. I don't know what that represents. Then the large reflection extending almost to the top of the chart is a fluid level, No. 4.

Mr. Mattingly: Q. Are any of the wavy portions of the line No. 2 in No. 4 reflections from tubing collars?

A. No, there was no tubing in the well when we made the test.

Mr. Babcock: There might have been casing collars, Mr. Walker.

A. There could have been some of them; no doubt are.

The Court: Inside casing collars?

A. There is a space between the sections of the casing. They don't come quite together, and the enlargement of the annular space at that point, those are recorded at times.

Mr. Mattingly: Will you state very briefly what you did subsequent to the test on March 6, 1936?

[190]

(Testimony of Cranford P. Walker.)

A. We made a large number of tests, primarily to check the accuracy of this calibrating equipment for measuring the velocity at which the waves traveled in the well. We did that by finding wells where the liner top was exposed, and at a known location, and making a record from which we determined the velocity at which the wave traveled to the liner top and back, and then set up our calibrating equipment at the well head, and determined what the velocity the shot traveled at, according to the calibrating equipment, and made a comparison of the two. We were trying to find out whether that device for measuring the velocity at which the wave traveled in the well would be commercially successful.

Q. How did the result of your comparison between your charted reflections from tubing catchers and liner tops compare with the timing of velocity indicated by your calibration tube 2?

A. In some cases the results or the check showed that the calibrating tube got excellent results, and in others it was way off. After that, when operators didn't place something in there at a known location to use as a measuring stick in the well from which to determine the pressure wave velocity, we recommended the installation of something on the tubing, the first time the tubing was pulled, to use for calibrating [191] the velocity at which the waves traveled, from which the fluid level could be accurately determined. And in every case where it was possible we made use of the liner top, because

(Testimony of Cranford P. Walker.)

that was usually pretty accurately located. In many cases we had to use the tube catcher as a yardstick, although its location was no infallible.

The Court: In making the calculations you use the speed of sound to determine the rate of travel of the pressure impulse?

A. Where we had a marker in the well, like a liner top, if it took the wave, say, 10% longer to get to the fluid and back than it did to get to the liner top and back, we knew that the fluid level was 10% farther down the hole than the liner. It was just a matter of straight proportions. Sometimes we measure the chart and sometimes we use the time scale to get that ratio.

The Court: But what was your calculation on the time scale? I mean, what did you use, the speed of sound?

A. Yes. As the speed of sound in well gas varies less than 800 to approximately 1470—less than 800 to over 1470 feet per second, it is necessary to get some measure of the velocity of the wave in each particular well.

The Court: That is the medium through which the pressure impulse must travel?

A. Yes, your Honor. And that wave velocity is very seldom uniform from top to bottom. It sometimes increases and it sometimes decreases as it goes toward the bottom of the well, due to [192] special conditions in a particular well.

Immediately following the tests on March 6, 1936, we made subsequent tests. During that period we

(Testimony of Cranford P. Walker.)

made demonstration tests, also measured fluid levels in the wells, and in some cases the operators questioned the accuracy of the equipment. They found that the fluid levels, as reported by us, were higher than the fluid levels that they found. That is, the fluid levels that we reported for the well operating were higher than the fluid levels that they found with the well shut down and determined by running a bailer into the well. So we were pretty much at sea. We didn't know what to do about it. The thing to do was to determine the pressure at the pump instead of the fluid level. We soon found that when the well started up and began making gas the fluid was lightened considerably. In some cases it actually came up the hole when the well was started up and producing, instead of going down. It seemed to be that the fluid level was almost valueless. So I started building up casing pressure, trying to eliminate that fluid, the weight of which wasn't known, and get the final fluid level as close to the pump as possible, and then from the casing-head pressure to determine what the pressure was on the surface. And not knowing any different, we assumed that what fluid was left above the pump was gas free, or practically so, and weighed the same as the oil out in the tank where the gas then escaped. So we used that method for quite a while, displacing all the fluid we could, not knowing what value or weight to give it [193] in determining pressure at the pump. Many companies, and the major companies in particular wanted that, instead

(Testimony of Cranford P. Walker.)

of a fluid level. A fluid level gave them something that told them they were not producing the well at its maximum capacity if the fluid level was any great distance above the pump or above the producing sand. It was some information, but not the kind of information that most of them wanted.

Mr. Mattingly: Q. Then, as I understand, you made some of these tests, and during the making of the tests you built up the casing pressure so as to attempt to push the fluid level down to the entrance of the pump; is that correct?

A. That is correct, yes.

Q. By doing that you then determined what your casing pressure was. What did that tell you with reference to the pressure at the pump inlet?

A. To determine the pressure at the pump inlet we took the casing pressure, and by means of a formula worked out by Mr. Dice of the General Petroleum, I believe, at that time, we found out how much to add to the casing pressure to give us the pressure at the fluid surface.

The Court: That is the weight of the gas?

A. The weight of the gas. Then to that pressure in the fluid surface we added the pressure which the remaining column of fluid then exerted at the pump at that time. The total then, the casing-head pressure plus the pressure exerted by the gas [194] column, plus the pressure exerted by the remaining fluid in the well gave us the pressure at the desired point, which was usually the pump.

(Testimony of Cranford P. Walker.)

The Court: You didn't know what the pressure of the remaining fluid was?

A. No. We assumed that it was gas free, around 40 pounds per inch, because that much pressure would be exerted at the pump, or a little less. That was where the bug came and we didn't know whether to go ahead with it or throw it all into the ocean or what to do, for a while. We went on to displace as much of the fluid as we could, where the operator wanted the pressure at the pump and would not be satisfied with a plain fluid level determination; and kept that up for quite a while. And they knew just exactly how we were arriving at it. We didn't know what the density of that remaining fluid was; neither did they; but it gave them information which was very valuable in many cases. It was very much better than no information at all, or better than straight fluid levels. We found fluid as light as six pounds; that is, it would exert a pressure as low as six pounds per each hundred feet of fluid column; six pounds per square inch; whereas, the average is around 38 pounds per hundred feet of fluid column.

The Court: Well, that is pretty light, isn't it?

A. Yes, that is very light.

The Court: 38 pounds per hundred feet? [195]

A. Water is a little over 43 pounds per hundred feet.

The Court: I see.

A. And this oil will average around 38 pounds per hundred feet of height of fluid column.

(Testimony of Cranford P. Walker.)

Mr. Mattingly: Q. Did you ever attempt to make density determinations about this time?

A. Yes. We call those also density determinations; displacing the fluid, and the ratio between the fluid displacement and the pressure required to displace the fluid, we called it the average fluid density and reported it as such to some of the operators. It was an average fluid density. We didn't know at that time that that fluid density was constant, but we were able to determine the average fluid density, because we may displace it a thousand feet with a certain amount of pressure, and we knew that was the average density of that column, from where we found it at the low pressure to where we found it at the high pressure. We first discovered that density of that fluid column was constant in December of 1936. Somewhat prior to that time we had suspected that it was constant. We made tests in wells where we used to maintain two different pressures, or three or more pressures, and in some cases they came out, by plotting fluid levels against casing pressure, they came out straight lines. And we suspected, although it was very much against our preconceived ideas, we thought that the farther down you went in that fluid column the heavier that fluid [196] became, because it was under so much more pressure and the gas was compressed so much more than it was at the top, that we had definitely made up our minds, when we started off with that conception, that that fluid could not be constant weight all the

(Testimony of Cranford P. Walker.)

way down, but got heavier and heavier as it went down. In some of our literature we actually said it displaced as much of the fluid as possible until the remaining fluid was compact. We later learned that you couldn't compact it; that the fluid density was constant regardless of how far you pushed it down the hole.

Q. How did you come to arrive at the final conclusion or become convinced that the density was constant in that fluid column?

A. That was, I believe, a test which we made for the Standard Oil Company in December at their Mountain View field, which is near Bakersfield, in December, 1936.

Q. Do you remember the name of the well on which that test was made, which finally brought you to that conclusion?

The Court: Well, was that the same well that the Standard Oil man testified to?

A. It was either Abadie or Wilson. I think it was Abadie No. 1. That was the first time we got up enough courage to admit that we had been converted to the constant density idea. We had had these other tests that plotted out a straight line, but we thought they were accidents rather than a fact.

[197]

Mr. Mattingly: Q. Will you state, if you can, when you first used the information as to the pressure obtained by the method which you had worked out for the purpose of determining the production capacity of oil wells?

(Testimony of Cranford P. Walker.)

A. If I remember correctly, that was at Fruitvale on some well we tested for the Western Gulf *Okl* Company. That was, I believe, January, 1937 or December, 1936. It was just a little later than this test on these wells where we tested this Abadie No. 1 for the Standard Oil Company.

Q. Will you state briefly to the Court the circumstances which *let* up to the development of the registration of the tubing collar echoes, as described in patent, 2,156,519?

A. Well, once in a great while we would get what appeared to be tubing collars on our charts, and about that same time, I believe it was along in December, 1936, we suspected that it had something to do with the length of the connection between our instruments and the casinghead of the well. And in the early part of March, 1937 we took to Maricopa—we had an assortment of pipe nipples so that we could vary the length of the connection between the casinghead and our instruments, and I had worked out certain lengths, multiples of the tubing joints that I wanted to try out, and it was on those tests at Maricopa for the Rio Grande Oil Company that we found which length it was that gave us true collars. Some lengths would give something that looked like collars, but they were not true collars. And [198] we found that the length of casing equal to approximately one-third of the tubing joint length gave us true collars. I believe that was March 6th, I think those tests were started, in 1937.

(Testimony of Cranford P. Walker.)

Q. Did you keep a record of any of the charts on which you used your different lengths of nipples for the purpose of bringing out those tube collar echoes?

A. Well, we no doubt have plenty of charts that would show that. I didn't bring any of them in with me, I don't believe.

The Court: That is No. 19 on the drawing of patent 2,156,519, is that right? A. Yes.

The Court: In other words, 19 would be a length of a definite ratio to the length of tubing?

A. Yes. We didn't use that adjustable length until later. We didn't use it very must at that time, because we found that we could predict from a known length of tubing just what length to put in there, so we used an adjustable sleeve. It was the length, your Honor, between the casing head and the diaphragm No. 23. That is, the significant length. It is from the casinghead of the hole to the diaphragm of the recording instrument.

Mr. Mattingly: Q. Do you have any typical charts, which have been made by the use of your instrument with this collar tuning or collar accenting apparatus, which would illustrate the type of chart which you could make as a result of using that [199] apparatus in connection with your recording device?

A. I think I have a short one here that shows the effect of tuning.

Mr. Mattingly: We have here a chart which

(Testimony of Cranford P. Walker.)

reads, "Well No. 109, date tested 12/5/41", which I offer in evidence as Plaintiffs' Exhibit 25.

[Printer's Note: Plaintiffs' Exhibit No. 25 is set out in full in the Book of Exhibits.]

The Witness: I have the original of these charts which I have just produced. Those charts are sensitized paper. The original comes right out of the instrument, and that is what we give to our customers. There is no negative. That is the positive and that is all there is. We use sensitized paper. This same type of paper that is shown here. The record is made directly on the piece of paper that is run through the machine.

Mr. Graham: But is it understood that these are not charts that were furnished to the companies, but a number of charts were taken, and of the number that were taken certain ones were given to the companies. These that you have produced here are the ones that were not given to the companies.

The Court: Taken at the same time and under the same conditions?

The Witness: Taken at the same time and under the same conditions. I think in this particular test there were three charts made like this. There was one of this type, which we didn't consider satisfactory, so we changed the tuning and made two of these; and gave one of them to the customer, and this is [200] the other one.

Mr. Mattingly: Q. Will you refer to Plaintiffs'

(Testimony of Cranford P. Walker.)

Exhibit 25 and explain what is represented by the two charts appearing on that exhibit?

A. That exhibit—the chart at the top has the number 1 on it, and the one at the bottom is No. 3. The top chart, No. 1, was taken with our instruments tuned to the tubing collars. No. 3, the one at the bottom, the length of pipe (18 of the drawing of patent 2,156,519) was changed to tune the instrument to casing joints.

The Court: The one on the bottom of the chart No. 3, those are all rarefaction waves; is that right?

A. Primarily, yes, because the impulse is created by discharging a slug of gas from the well, instead of injecting a slug of gas. The well was under pressure. A little gas was discharged to get the impulse. On our equipment, when the impulses or echoes start toward the bottom of the chart, that is created by a wave of rarefaction. If it starts toward the top it is a pressure wave. Both of these charts of Exhibit 25, the pressure wave was initiated by letting out a slug of gas from the well.

Mr. Mattingly: Q. And the reflection from the casing joints, which are represented here on what is called chart No. 3 of Plaintiffs' Exhibit No. 25, those appear to be recordings initiated by waves of rarefaction. When this wave hits the gap [201] in the casing a wave of rarefaction is reflected back to the casinghead. The tubing collar reflections, which are represented on chart No. 1 of Exhibit 25, those were initiated by waves of compression.

Q. Mr. Walker, when you first started into the

(Testimony of Cranford P. Walker.)

field of finding fluid levels by this apparatus which you have described, what was the reception that was given to you by the commercial oil companies?

A. Well, they all seemed very happy that something had been produced that would enable them to find out what was going on at the bottom of a pumping well without having to remove the pumping equipment from the well.

Q. Did they accept immediately this information, which you were giving to them as to the location of the fluid levels and determination of pressures, as being correct?

A. The greatest step of evolution that we made was when we could show them every collar in the well. Before that there were a lot of doubting Thomases, particularly among those who had not investigated our equipment. The major companies had made a pretty thorough investigation, but there were many small operators who had not made such an investigation, and they were very skeptical in many cases. The man in the field usually wanted to pump his well clear to the bottom and do the job a hundred per cent. At that time everybody was trying to get all the oil he could before his neighbor got it. They are supposed [202] to have quit it now. But at that particular time there was no proration, voluntary or otherwise, and every fellow wanted to get all there was before his neighbor took it. And every production foreman that was found with a well that he wasn't pumping clear down to the bottom, but pulling it out as fast as it ran into

(Testimony of Cranford P. Walker.)

the well, it was a black mark against him. And we found so many of them that were not pumping their wells down that they were inclined to doubt the accuracy of our results. We were striving to find something that would convince them, and when we discovered how to record these tubing collars our trouble seemed to be over in that respect. They were convinced when we showd them charts where they could count their own tubing collars and show just exactly where the fluid level was. That gave them more confidence in this reflection well testing art than any single step, I believe.

Q. Will you state whether or not your method of obtaining fluid level determinations, pressure determinations and production capacity determinations have been accepted by the oil umpires and those responsible for enforcing the proration agreements?

A. Yes. A voluntary proration was established on a large scale here in the middle of 1939. Before that time they had to demonstrate the capacity of the wells by actually producing them, flowing them or pumping them. But the oil company engineers got together and agreed upon a test which would indicate the capacity of the well, without actually having to move in expensive [203] equipment that would pump their wells to full capacity, and those methods consisted of measuring these hole pressures with a pressure recorder run in on the pump, or this reflection method of ours. And both were adopted

(Testimony of Cranford P. Walker.)

as a means for determining the well capacity on which their allowables would be based.

Q. Does that condition still exist in the oil umpires' office in California here?

A. It is a factor, but it isn't the only factor at the present time, since the government has taken over and the wells operate under the supervision of the Petroleum Coordinator. That is given weight, but it isn't the only factor at the present time.

Q. Has your method of determining these fluid levels, pressures, densities and production capacities been accepted in any other part of the country than California?

A. Yes. In Kansas, where proration is enforced by law, our method is accepted as a legal method of determining the well capacities. I was instrumental in having our methods accepted in Kansas. We had no difficulty in getting them accepted back there. As soon as we showed them that we could record tubing collars clear to the bottom of the well they all lined up in favor of this theoretical method of determining potentials.

The Court: Do they use that extensively in California now? [204]

A. It is still used quite a bit, but before the government took it over a potential was the big factor in determining well allowables. But now there are many other factors that are given weight in addition to the well's capacity. It is still acceeptable as one of the factors.

(Testimony of Cranford P. Walker.)

Mr. Mattingly: Q. Did you encounter any objection to your methods when you attempted to introduce them into Kansas?

A. Yes. The Echometer had been back there working before we took our equipment back, and they at that time were not able to record the tubing collars far enough down to determine the fluid levels accurately where the wells were small wells and fluid levels were close to the bottom.

Q. Do you know and did you know at that time who was operating the Echometer?

A. The International Geophysics, Inc., headed by Mr. J. J. Jakosky.

Q. Did you know Mr. Jakosky?

A. I knew of him and had seen him and met him. Yes, I knew him.

Q. When did you first meet Mr. Jakosky?

A. I met him at Huntington Beach on November 7, 1936 when we were making a fluid level test in a well for the Union Oil Company, known as Copeland No. 19. He came to the well while we were making the test in company with Mr. Basil Kantzer, an engineer for the Union Oil Company, and had a camera with him. Mr. Kantzer introduced [205] him to me and told me that he was a man who did research work for the Union Oil Company and he would like to look at our equipment and get all the information, and asked for permission for him to photograph the equipment, which was very unusual, but there was nothing else for

(Testimony of Cranford P. Walker.)

us to do, since the request was made by a company that was giving us a large amount of that work. At that time we could do nothing else but consent to his taking pictures of our equipment.

Q. At the time of that visit of Mr. Jakosky to the well on which you were using your apparatus, was there any other company or competitor in the field of making these fluid level determinations by the use of these sounding methods?

A. None that we knew of.

Q. When did you first learn that there was a competitor in the field?

A. I heard about it, I think it was in June or July of 1937.

The Court: That you first heard of Jakosky's efforts——

A. Yes.

The Court: ——or the Echometer?

A. It is one and the same thing. Someone told us that they had a truck down in Dominguez field trying to do the same thing we were doing. I believe that was some time in July.

Mr. Mattingly: Q. Did I understand you to say, Mr. Walker, that Jakosky, the International Geophysics, and Echometer are all one and the same thing with reference to this Echometer [206] apparatus?

A. They were present, yes, when Echometer was first brought out. After I found there was a competitor in this field, I heard that they were trying to record collars, and trying to determine bottom hole

(Testimony of Cranford P. Walker.)

pressures, just as we were doing, and I was very much disturbed by it, of course, because I felt that there wasn't enough of that type of work for two people in California, so I immediately began preparing patent applications to cover the method that I had managed to develop for testing these wells, and write material for the applications on this method of determining bottom hole pressures, by depressing the fluid, and building up casing pressure; by the method of determining the fluid level; by recording and counting collars; the method of tuning, which I had worked out at Maricopa; also methods of tuning electrically.

The Court: Are you reading?

A. No, all I have is just a bunch of dates, which everybody is welcome to see.

The Court: I have been still thinking about this chart; the pressure waves and rarefaction waves. I understood you to say that you knew, before you applied a carbon microphone, or the other kind of diaphragm microphone, that you would get a rarefaction wave from the perforated casing in the well, or perforated liner, as distinguished from the pressure wave above there.

A. I did not mean to say I knew it, if I did. I said [207] I knew that a carbon microphone would record a pressure wave, or a rarefaction wave.

Q. Did you know that you would get rarefaction waves in wells? That is what I am trying to get at.

A. No, not at that time.

(Testimony of Cranford P. Walker.)

Q. You know that now; but did you know it then?

A. No, but to get a true reproduction of what is reflected from the well it will have to work both ways. Most pressure waves are immediately followed by a rarefaction wave. It is much more perfect to have something that will exactly reproduce something that will come from the well, than to have something that will produce only half of it.

Q. Now, you know that you get rarefaction waves, where you don't get a pressure wave, instead of a rarefaction wave following a pressure wave?

A. A pressure pulse; sometimes there isn't very much of a rarefaction zone following it; by adjusting instruments we can minimize that rarefaction wave that follows the pressure wave, but just a single pressure pulse, there isn't very much rarefaction following it.

Mr. Mattingly: Q. Prior to the time that you selected this equipment, you had some idea of what sort of thing to expect to find in a well; that is, you knew you would find obstacles, such as tubing collars, liner tops, tubing catchers, which would constrict the space; you knew that before you started working, did you? [208]

A. I did not know an awful lot about it, but I wanted to have something which would show exactly what was in there, and it turned out to be very fortunate that I did select the type of re-

(Testimony of Cranford P. Walker.)

corder I did, because I ran into all those complications, as soon as I got started in the field.

The Court: Some emphasis seems to be placed upon the importance of a recorder being part of this method. If that is the case it strikes me it would be important if you could get an instrument that will indicate to you by a diagram the different kinds of waves that you are running into. I am not yet getting what was in my mind, whether or not you knew or expected to find rarefaction waves from the perforated casing.

A. No, that wasn't anticipated at that time. I didn't anticipate it. It was just a fortunate choice of equipment that I made that enabled us to get all those things after we got into service.

The Court: What made you think you would get any rarefaction waves?

A. Because in studying sound, they teach you that any pressure wave is followed by a rarefaction wave. That is, sound which is repeated, vibrations, are bound to be all pressure waves and are followed by an equal wave of rarefaction. The single pressure pulse is a little different, I believe. The rarefaction wave that follows the single pulse is a little different from a rarefaction which follows an oscillation ether or sound wave that repeats.

The Court: Well, was that rarefaction wave coming from [209] the perforated casing, the rarefaction wave following a sound pulse, or the one following a pressure impulse?

(Testimony of Cranford P. Walker.)

A. It didn't have to follow anything. If you had discharged that gas or impulse into the open pipe, say a thousand feet long, when the wave reached the end of the pipe you would get a wave reflected back. A low pressure wave or a rarefaction wave would be reflected back, starting into that piece of pipe. So that when you start those perforations, that is similar to a wave when it emerges from the end of an open pipe.

The Court: Then your rarefaction wave is the same return wave that you get from the surface of the fluid, isn't it?

A. It is similar, except it is a rarefaction wave instead of a pressure wave.

The Court: In other words, you get a rarefaction wave from the surface of the fluid?

A. No. The pressure wave itself is reflected from the fluid. Nothing happens except it bounces back, just as it goes down and hits the fluid. It is a high pressure zone.

The Court: Let me see if I understand you correctly. The reason why you chose the type of microphone that you did choose in making your first equipment for the recordation of the pressure wave and the rarefaction wave, if I understand you correctly, was because on the theory of sound pressure waves are followed by rarefaction waves?

A. That is exactly correct. [210]

The Court: And it wasn't, am I to understand, because you expected to find rarefaction waves by themselves, as you have found?

(Testimony of Cranford P. Walker.)

A. That is correct, as I remember it, your Honor.

Mr. Mattingly: Q. You were testifying that you had assembled the information together necessary to file patent applications. Did you actually file those applications?

A. Yes, on all those which I mentioned yesterday.

Q. And you mentioned, I believe, that you filed an application covering the method and apparatus for finding fluid levels; is that correct?

A. Yes. That was the application which resulted in the patent in suit, 2,156,519.

The Court: Just a minute. Do you claim that you were the first one that discovered that rarefaction waves return from a perforation in oil well casing, rather than pressure waves?

A. Well, that is what you would expect to get, but as far as I know it was the first——

The Court: No. Are you sure you are the one who discovered that?

A. I believe I am the one who made the first record of that fact. Whether it was a discovery or not, I don't know. We didn't claim it as such. And incidental to that, the top of the perforation is frequently used as a target in there by means of which to locate the fluid level. I shouldn't say frequently; [211] occasionally it is used, when we haven't accurate information on the tubing string, the joints and how many there are, we sometimes have used that as a known point which is accurate. The be-

(Testimony of Cranford P. Walker.)

ginning of the perforations is accurately known.

The Court: Yesterday it was stated, in the course of the testimony during the day, by someone, that those spaces in the joints of the casing collars reflected on the recorder. Now, are those pressure waves that return and are reflected on the recorder, or are those rarefaction waves?

A. If you inject a pressure wave into the well, those are waves of rarefaction and come from that open space between the joints.

The Court: So that would be on one side of the line?

A. On one side of the line. A different side of the line from your pressure wave. And we do record those frequently. And one of our exhibits shows a record where we used the casing joints to measure the distance to the fluid in preference to the tubing collars. That is what causes so much trouble in recording tubing collar echoes, with the interference of these casing joints.

The Court: The wave that comes from that spacing, as drawn on the diagram by counsel, is a rarefaction wave?

A. If we start out with a pressure wave that is a rarefaction wave.

The Court: But the thing that comes back from the tubing joints; that is to say, a projection into the annular space, [212] is a pressure wave?

A. That is correct.

The Court: So that a recording of that would give you the tubing joint on one side of the line

(Testimony of Cranford P. Walker.)

and the casing and spaces on the other side of the line; is that right? A. That is correct, yes.

The Court: You didn't know that when you started, though?

A. No. We knew, at least theory would teach us that is just what would happen, but we didn't know that it would happen in an oil well. I didn't know it. Ordinarily those reflections are so very close together that they almost overlap in many cases, so that it is just a saw tooth type of record that you get.

Mr. Mattingly: Q. The ordinary pressure pulse or a shot of gas going down into the well and hitting an obstacle, would normally produce a pressure echo extending in one direction, that would be followed ordinarily with a resultant rarefaction wave extending in the other direction, would it not?

A. That is according to the theory of sound.

Q. And if you had selected a microphone which had this directional characteristic that would show whether it was a pressure wave impinging on the microphone or whether it was a wave of rarefaction impinging on it, you would have produced a true record of the pressure which is received from that echo, would you not?

A. That is what I had in mind. It was purely a research [213] proposition and I wanted to find out the facts, just what happened.

Q. If you had selected a non-directional microphone, you would have had this result, would you not (indicating) where a microphone, in respond-

(Testimony of Cranford P. Walker.)

ing to a pressure wave, would produce a wiggle in the line extending in one direction. Then when a rarefaction wave impinges on the microphone, that is this rarefaction wave which would follow the pressure wave which would impinge on that, you would get a second recording of a wave in the same direction as this first part of the wave; is that right?

A. That is true with a hot wire microphone. That would be true of a non-directional microphone.

Q. Then wouldn't it be true that the reason you selected a directional microphone was so that when you got two humps in here you would be able to tell whether that was really one obstruction or two obstructions?

A. That was possibly a part of the consideration. I didn't want anything that was false. I wanted a true record of the reflections.

The Court: That arrow that he has drawn, pointing to the left, on the top one, you would get that same kind of recordation from the casing space and joint space, wouldn't you, if it immediately followed a tubing collar? You have drawn a worm on the board there. [214]

A. If it immediately follows the tubing collar or casing joint, you would get that same——

Q. The top one would be the tubing collar, wou'dn't it?

Mr. Mattingly: That would appear to be the tubing collar.

(Testimony of Cranford P. Walker.)

The Court: The next one would either be a rarefaction wave naturally following the pressure wave, or it means a casing space, is that correct?

A. Yes, that's possible.

Mr. Babcock: Mr. Mattingly, in order that the record may be clear, may I ask a question: Isn't the difference between the top curve you have drawn and the bottom one the fundamental difference in the record made by the Depthograph and Echometer?

The Witness: Yes, that is, according to my understanding of it. To simplify these things, we call a wave of rarefaction a negative wave, and a pressure wave a positive wave. I believe that is used in the literature also on sound. It is only an arbitrary designation.

Mr. Mattingly: Q. And that wave of rarefaction, or reflection representing rarefaction, would be followed by a wave compression as a result of the creation of the rarefaction wave, would it not?

A. That is my understanding of it.

Q. In that event you would have a record such as I have just drawn, in which the uppermost loop is extending in [215] a negative direction, whereas in the case of an obstruction or constriction, the uppermost loop would extend in a positive direction?

A. That is correct; the direction of the initial movement indicates what a constriction or enlargement is; in other words, whether it is a tubing collar, or a casing joint.

(Testimony of Cranford P. Walker.)

Q. You mean by initial movement, the line is coming down here straight, and it starts off with a straight line, and the direction of the start of that is the thing that tells you whether or not it is a compression wave or a rarefaction wave, is that right? A. Yes.

The Court: In the record of a perforated casing, they would all start from the center of the line, over the line, and go in a negative direction, coming back to the line, and crossing over to the positive side of the line, is that right?

A. In our instruments they sometimes cross over, and sometimes they do not. Partly a bounce, and partly a wave of rarefaction, I presume. Ordinarily that perforated zone is so long that the pressure wave following the rarefaction never shows up.

Q. So it just comes back to the line, and then it goes straight over, goes like counsel has indicated?

A. No, it comes back on the line and goes straight.

Mr. Mattingly: Q. That is a matter of adjustment of your [216] instrument?

A. Yes; damping it so it doesn't overshoot.

The Court: Is that what you mean by tuning?

A. No, that is something different.

Q. Damping is a mechanical adjustment?

A. Yes.

Q. That is some screw, or something like that on it? A. That is correct.

Q. In your mechanical recorder, with the light

(Testimony of Cranford P. Walker.)

and mirror, your needle works back and forth. Is there any bounce of that needle, or does that accurately come back to the line when the wave stops and then goes on straight?

A. Yes, we have a damping adjustment on it, which, when opened up, and the damping is made ineffective, there is a bounce.

Q. Resulting from the weight of it, and the jiggling back and forth?

A. Possibly, whichever it shows, whether that is the weight of the diaphragm or the weight of the gas.

Q. You call it a bounce?

A. That is a good name for it. Unless you call it an overshooting.

Mr. Mattingly: Q. I believe that you stated you gathered together the information and prepared, or had prepared, and filed a patent application of your methods of determining the pressures and densities and production capacities? [217]

A. Yes.

Q. Is that the application which resulted in reissue patent 21,383?

A. It is. The patent application which finally resulted in patent 21,383 was issued as an original patent, having another number, before the reissue was applied for.

Q. And the original patent or application about which you have just testified issued on June 6, 1939, is that correct?

(Testimony of Cranford P. Walker.)

A. It was issued early in 1939. And patent 2,156,519 was issued on May 2, 1939.

Q. What did you do with reference to the competition by the International Geophysics Company immediately subsequent to the issue of those two patents?

A. They were notified of their infringement of those two patents.

Q. Then what happened?

A. There was a little correspondence, I believe, and Mr. Jakosky, who was head of the International Geophysics at that time——

Mr. Graham: Your Honor, this testimony is objected to as to a notice against the International Geophysics Company. They are not a party to this suit.

The Court: There was something in the pleadings here.

Mr. Mattingly: The pleadings show that the defendant purchased the business and equipment of Echometer from the [218] International Geophysics.

Mr. Graham: The question is of notice in this case, your Honor, and the International Geophysics Company is not a party to this case.

Mr. Mattingly: This testimony is not for the purpose of proving notice given to the defendant.

Mr. Graham: Will Counsel state what it is for?

Mr. Mattingly: Yes, it is for the purpose of bringing out the history of the development of this, and also for the purpose of leading up to the

(Testimony of Cranford P. Walker.)

evidence which I have insisted should be heard by this Court in connection with the attack on the validity of Patent 2,209,944.

Mr. Graham: I don't see the materiality of it, whether or not the International Geophysics had notice of infringement. It certainly would not go to the defendant in this case,

The Court: I am going to let the evidence in. Objection overruled.

Mr. Mattingly: Q. I want to know just what occurred insofar as your personal knowledge is concerned, between you and the International Geophysics, subsequent to the giving of a notice to the International Geophysics of infringement of those two patents.

A. I don't recall what happened between me personally and the International Geophysics organization.

Q. Did you have any meetings with Mr. Jakosky?

A. Yes, I had several meetings with him. [219]

Q. What was the purpose of those meetings?

A. To work out some arrangement by which they could continue to operate under a license from us, under the two issued patents that have been mentioned. Those negotiations or meetings took place over a period from about the middle of July, 1939, I believe, until I think it was some time in February, 1940, and Mr. Jakosky got so unreasonable that we just had to terminate the negotiations. He would have had us pay him a royalty

(Testimony of Cranford P. Walker.)

instead of his paying us a royalty, the way he wanted it written, before we got through with it.

We put considerable pressure on the patent office to have them issue some patents, which were being infringed by the International Geophysics. Those patents were 2,156,519, and Re. 21,383. We wanted Mr. Jakosky to know that we had those patents, and he was going ahead using our method, a method that I had developed, indiscriminately, and making commercial use of them every day. At the same time I had applications in covering those methods, and there was considerable expansion of the service contemplated in Kansas early in 1939, and I felt that the quicker that we let him know what the situation was, the less he would have expanded, and the easier it would be to get him to stop his expanding. So we wanted the patents to clear up such matters, to get those patents brought out as soon as possible.

Mr. Mattingly: Mr. Walker, have you been able to find a chart made by the Depthograph Company, using the tuning for [220] tubing collars which you testified about yesterday?

A. Yes, since I testified as to the date when that work was started, I tried to find a chart which was as close to this date as possible.

Q. Exhibit 25, which was introduced yesterday, is a chart which employed this tuning?

The Court: Did any of the charts which you introduced yesterday have the calibration apparatus?

A. Calibration equipment was not used at the

(Testimony of Cranford P. Walker.)

time the charts were made, but it was used during the tests on which most of these charts were made, and I believe while all of them were made. It is not used at all now; that is, which is referred to as 53 to 67 on the drawing of patent 2,156,519. It has not been used since we began tuning to bring out the collars.

Mr. Mattingly: Q. Will you identify the chart you have just produced?

A. This is a chart which was made on a well in El Segundo on April 24, 1937. It shows the effects of the tuning.

Q. Will you describe to the Court how that shows the effect of the tuning, and will you please show that to the Court as you are describing it?

A. It begins with a break in the line which occurred when we discharged the gas into the well. The larger dots represent seconds, and the others are tenths.

The Court: That is about four-tenths of a second? [221]

A. Yes, where the gas was released into the well. Then the chart has a serpentine appearance for about two inches, which occurred after the initial discharge, and also includes the time when the valve protecting the *diagram* was opened. About three-quarters of an inch——

The Court: We will call that No. 1. Now, what were you stating about three-quarters of an inch?

A. .65 seconds, approximately, from the beginning of the chart there is quite a movement of

(Testimony of Cranford P. Walker.)

the light beam, which represents the point where the safety valve ahead of the diaphragm was opened.

The Court: The diaphragm valve?

A. Yes.

The Court: That is No. 2.

The Witness: Then there is a series of oscillations appearing like the teeth on a saw, and each peak represents reflections from a tubing collar.

The Court: Each peak. That means the mark in the direction of the top of this chart?

A. That is correct, your Honor.

The Court: That is what you call a peak?

A. Yes.

The Court: What is this down here at the bottom; is that a peak?

A. That is a swing-back or over-travel as a result of that peak. [222]

The Court: Is that the bounce?

A. It is a bounce.

The Court: Are those bounces or are they rarefactory waves?

A. There is a wave of rarefaction mixed in there. When the wave ran off the tubing collar the wave of rarefaction was reflected, and that is incorporated in that swing. It is a tuning arrangement, so that it irons out or smooths out the record, so that you could distinguish between where the pressure wave began and where the wave of rarefaction began. The distance between pressure waves represents the tubing joints.

(Testimony of Cranford P. Walker.)

The Court: How do you account for this sort of bull neck here in the beginning?

A. That was a surge of the gas from behind the diaphragm back in front of the diaphragm. When it received this pulse here the gas flowed around the by-pass in behind the diaphragm, then surged back, due to its inertia, to the front of the diaphragm and the diaphragm moved in response to that surge.

The Court: I see. That is, the whole diaphragm?

A. Yes.

The Court: And these are just oscillations of the center of the diaphragm?

A. Those are high-frequency oscillations, the diaphragm moving as a whole.

The Court: I see. You have a pencil mark here of some kind. That is eight-tenths of a second?

[223]

A. That represents ten collars from there to this start. That zone is interrupted by operating the valve. We take that space and lay it over here and find out how many collars belong in that space. This pencil mark represents the end of ten joints of tubing.

The Court: So that the first five seconds after the introduction of the sound you don't consider an accurate measurement due to the disturbances of the microphone?

A. In most cases it is not possible to count the collars in that zone. But we can bridge that zone, as we call it, by taking the length of the zone and

(Testimony of Cranford P. Walker.)

then laying it over where the collars will go and counting off the number of collars that would fit into that.

The Court: Where the pressure impulse has steadied down to a rgular gait?

A. That is correct.

Mr. Mattingly: Would you mark one or more of the peaks that represent tubing collars?

The Court: You have got "static" here. What does that mean?

A. That means that the well was not producing at the time the test was made. The point marked "3" on the card is one of the many peaks representing collars on the chart.

The Court: What is this here in the middle of it, 5.8 seconds, where it narrows down? [224]

A. That is probably where there was interference between casing joints and tubing collars, where the casing joints tended to cancel out the tubing collars, or it could be where there was a group of either——

The Court: Mark that "4" in red pencil.

A. It could be a group of joints which are a little longer than the average or possibly a little shorter. And the next deflection—the next major deflection, which is about a little over seven and a half seconds along the chart,—which is numbered 8—are reflections from the fluid surface. I think that describes the significant points on the chart.

Mr. Mattingly: I offer the chart produced and just described by the witness as Plaintiff's Exhibit 26.

(Testimony of Cranford P. Walker.)

[Printer's Note: Plaintiffs' Exhibit No. 26 is set out in full in the Book of Exhibits.]

The Court: You have got marked here "Fluid level 196 jts"—that is joints, I suppose?

A. That is correct.

The Court: ——"4586 feet." That is the calculation you made on that well?

A. Yes. 196 strings times the average joint length, which our customer gave us, gives us that depth.

The Court: Did you arrive at the depth of it by calculating the speed of sound?

A. No, we didn't use the speed of sound. We simply counted the joints.

The Court: Can you do that from this chart?

[225]

A. Yes. They had told us what the average length of these joints was, and we multiplied the number of joints shown on the chart by the average joint length to obtain the depth to the fluid of 4586 feet.

Mr. Mattingly: Q. Mr. Walker, in addition to the activities of the Depthograph Company in measuring fluid levels and giving the other services of pressure determinations, density determinations and well capacity determinations, has your company ever manufactured and sold or leased any Depthograph instruments?

A. Yes. There have been two leased and one sold. One was leased to the Texas Company and

(Testimony of Cranford P. Walker.)

the other one to the Shell Oil Company. The one leased to the Shell Oil Company is the apparatus which was referred to by the witness Gilbert in his testimony here. We are receiving rental and royalty from The Texas Company unit, and royalty from the Shell Company unit.

Q. Mr. Walker, do you have any photographs of the Depthograph apparatus about which you have been testifying here? A. Yes. I found two.

Mr. Mattingly: I would like to offer in evidence the two photographs produced by the witness, as Plaintiffs' Exhibits 27 and 28. The machine is 27 and the man and machine is 28.

[Printer's Note: Plaintiffs' Exhibits Nos. 27 and 28 are set out in full in the Book of Exhibits.]

Q. Mr. Walker, will you refer to Exhibits 27 and 28 and briefly identify the essential portions of the apparatus which is shown? [226]

A. Well, the black object at the extreme left of the photograph is what we call the recorder, it contains the optical system. And hanging onto that recorder in front of it, with the curved surfaces on it, is the camera. And I shall call that "A".

The Court: That is with a lens in front, a round lens. That is the camera?

A. It looks like a lens. It is a dial of a meter.

The Court: All right. "B" is the camera.

A. Well, down at the lower right-hand corner, the cylindrical bright object extending up almost

(Testimony of Cranford P. Walker.)

half way up on the recorder is what we call a receiver. It contains a diaphragm. That will be "C".

The Court: Before you get away from these bright objects on here, is this business with a valve on the top and looks like an oil gun, is that part of "C"?

A. That is a part of "C". That filters the gas which is allowed to pass back of the diaphragm into the space occupied by the mirror and its mechanism. That is shown as 25 on the drawing of 2,156,519. I suppose we should call that "D" on this photograph. Then coming down to the lower left-hand corner of the photograph there is a piece of pipe with a cap on the end of it which we call the impulse chamber, and it is a chamber that we store a little gas in to create the impulse in the well.

The Court: That is 12 on the drawing of 2,156,519? [227]

A. Yes, your Honor. And at the right-hand end of that chamber there is a gadget with quite a number of bolts through it, which is the quick-opening valve for discharging the gas from that impulse chamber. And that is "F" for the quick-opening valve. I believe the only other significant part left is the protecting valve, which is the handle in the background just behind the handle of the quick-opening valve. That is shown as No. 21 on patent 2,156,519. I will mark the valve "G."

Mr. Mattingly: Q. Is the flask referred to by

(Testimony of Cranford P. Walker.)

the number 11 in patent 2,156,519 shown on this photograph, Exhibit 27?

A. No, it isn't. It is normally carried on the truck, but it isn't visible in this photograph.

Q. Is there any part in the photograph which represents the tubing 13 as shown on patent 2,156,519?

A. Yes. There is a hose down in the lower left-hand corner of the photograph, which I will designate as "H".

Q. Will you tell the Court what that part is which the Court referred to as a stereopticon effect?

A. That is just a hood to keep the light from getting into the recorder and fogging the film. There is another part on that which we could identify, since the Court asked a number of questions about it, and that is part 52 on the drawing of 2,156,519, which shows on the photograph, and it is a sensitivity control. There is a damping valve on top of "D". I will mark it "J". "J" belongs about where the character 24 is shown on the [228] drawing of 2,156,519, but it is not shown on the drawing.

The Court: That is an addition, then "J" is an addition?

A. It is a detail that has been used ever since we started, but it wasn't put into the patent drawing.

The Court: Where is the tuning joint?

A. The tuning is not shown on that photograph.

The Court: You didn't tune this well?

(Testimony of Cranford P. Walker.)

A. No. There was probably a liner top exposed or some other marker from which the fluid level could be determined.

The Court: Where does your apparatus begin in an oil well, where the black pipe goes into the white one?

A. That is correct.

The Court: All right. Mark that "L".

Mr. Mattingly: Q. Will you identify the flask shown in photograph Exhibit 28, Mr. Walker?

A. Well, in the truck there is an oil can visible and there are two flasks, one above the other. We call them bottles; gas bottles.

The Court: Is the tuning apparatus here?

A. No, the tuning isn't shown there. It wasn't used.

The Court: Is all this your equipment that shows above the derrick floor?

A. All except the valve. That is, our equipment begins at the valve. [229]

Mr. Mattingly: Q. Will you mark that valve with the letter "N"? I will designate the bottom one of the two with the letter "M".

The Court: Is this an identical piece of equipment as shown in 27?

A. I believe it is.

Cross Examination

By Mr. Graham:

Q. Mr. Walker, referring to these exhibits, 27 and 28, about when and where was this exhibit 27 taken?

(Testimony of Cranford P. Walker.)

A. I think that was in 1939, taken on a Union Pacific well at Wilmington. Exhibit 28, I believe that was the same year. I can find those exact dates, if it is important, but those are just guesses I am making now. These photographs, exhibit 27 and 28, however, illustrate the type of apparatus, in its essential details, that we were using in the latter part of 1939 and 1940, and from then on to the present time.

Q. Mr. Walker, I understood you to testify originally, before you were particularly asked about specific applications, that you filed applications on these different developments that you made; is that correct?

A. I made that statement, that I had filed applications on the developments that I had made.

Q. Have you filed other applications than those that have [230] been specifically referred to in your direct examination?

A. Yes. The ones to which I testified were filed in September and October, I believe of 1937. I think those applications are directed to apparatus or methods which I have testified to on direct examination.

The Court: Tell us how many applications there were.

A. As I remember, there were three filed about the same time.

The Court: Other than these?

A. No, not other than these; including these.

(Testimony of Cranford P. Walker.)

Mr. Graham: Q. Well, there are three of these, Mr. Walker, aren't there?

The Court: Three granted and one abandoned. There are four, aren't there?

A. Well, one is a division of the original application. One, if I remember correctly, covered the method of depressing the fluid by building up pressures or changing the gas pressure in order to determine bottom hole pressures and well potentials. I think that was one application. And then another original application covered the method of counting the collars to determine fluid levels, using liner tops and catchers for the purpose of determining fluid levels, tuning for the purpose of accenting the collars and it also covered some structural features of the instrument. The third one I referred to covered all electrical [231] apparatus, including electrical tuning for the same purpose as accenting the collars.

The Court: Is that one of these?

A. No; but I mentioned it in the direct examination testimony as applications which I prepared material for and applied for at that particular time.

Q. One of these that you refer to is serial number 164,534, filed September 18, 1937, is it not, that is referred to in page 3 of the reissue, column 1, line 73.

The Court: "And in my co-pending application, serial No. 164,534."—is that what you are referring to. A. Yes.

Mr. Graham: Q. I understand, Mr. Walker, that

(Testimony of Cranford P. Walker.)

that is the one that is directed to an electrical system instead of a mechanical system, shown in the patents in suit; is that correct?

A. Such an application was filed, but Mr. Graham, I can't identify it by application numbers, because, unfortunately, I have never familiarized myself with them by numbers.

Q. Will you permit counsel to say?

A. Yes.

Mr. Mattingly: Yes, that is the application.

The Court: That is the application for electrical tuning and recording?

Mr. Mattingly: That is correct, your Honor.

[232]

The Court: And the use of what we call an electrical microphone?

Mr. Mattingly: That is right.

The Court: Rather than mechanical?

Mr. Mattingly: That is right.

The Witness: Such an application was filed in September, 1937.

Mr. Graham: Q. Have you a copy of that, Mr. Walker—I understand that counsel was to have a copy of that in court.

Mr. Mattingly: I have a copy of that in court, that application.

Mr. Graham: Will you kindly produce that application?

Mr. Mattingly: This is the certified file wrapper of that application and contents of the file wrapper, which I ordered immediately after the taking

(Testimony of Cranford P. Walker.)

of the Walker depositions, at Mr. Babcock's request, and it contains all of the application papers up to that time At the time I ordered them there had been entered in that application file the following papers: No. 1 is a request for further explanation of the patent office action of January 14, 1942, and that paper is dated April 6, 1942; an official United States patent letter in response to that request for further explanation, the letter being dated April 11, 1942; an amendment dated April 7, 1942, which was prepared and filed in that application by me; and an examiner's amendment, which is an amendment prepared by the examiner in the Patent Office, dated July 22, 1942; and an official notice of allowance in that application, dated July 2, 1942 —which [233] completes the file wrapper of that application. May these papers be attached to the file wrapper, and the file wrapper, with papers attached, be marked for identification as Plaintiffs' exhibit.

The Clerk: L.

Mr. Mattingly: I might point out that the copies which I have referred to as these additional papers are merely typewritten copies, but my official office file is here.

Mr. Graham: We will take your word for it, Counsel, if you say they are correct copies.

The Court: What is that, 164,534?

Mr. Graham: Yes, filed September 18, 1937.

The Court: Is that still in a pending status?

(Testimony of Cranford P. Walker.)

Mr. Mattingly: The present status of that application is that it has been officially allowed, and is merely awaiting payment of the final government fee to issue as a patent. I do not believe that the final fee has as yet been paid in the case.

Mr. Graham: Q. Mr. Walker, is there any way with your system of distinguishing one restriction in the annular space from another; that is, can you tell whether you have a tubing catcher or liner top that causes a particular reflection?

A. There is a little difference between the refletcions from the tubing catcher and liner top.

Q. Then, is your answer yes?

A. Ordinarily, yes. [234]

Q. Will you please tell how you can distinguish between the two?

A. A tubing catcher, when you run off of the bottom and of the catcher there is a negative wave reflected. Assuming it is a positive from the top end, so that it has a greater tendency for the light beam to be reflected from below to the center line than it does from the catcher, it tends to stay up, and the reflection is recorded from the catcher.

Q. You mean that in one case you get also a rarefaction or negative wave?

A. From the catcher.

Q. That depends on how the catcher happens to be built, is that right?

A. No; the body of the catcher is usually three or four feet long. When the wave hits the top of

(Testimony of Cranford P. Walker.)

it, it reflects a pressure wave, and when it leaves the bottom there is a wave of rarefaction reflected.

Q. If that is true, then what is the difference between the tubing catcher and the fluid level?

A. The same difference there is between a tubing catcher and a liner top, the reflection from the fluid level is similar to that from the liner top.

Q. The fluid extends all the way across and fills the entire space, whereas, the liner top just extends in a little way, a part way restriction, you might say, isn't that right? [235] A. Yes.

Q. You say that they give the same reflection, the top of the liner and the fluid level?

A. They are similar; the characteristics are similar. Frequently you get a much bigger reflection from the liner top than you do from the fluid, depending upon your liner, and how far down inside of the liner it is to the fluid level.

Q. If you don't know where the fluid liner top is, you don't know whether you have the fluid level or liner top, do you?

A. That is correct.

Q. Referring to patent 2,156,519, page 4, second column, beginning with line 43, it states:

"Thus by observing the effects of a series of pressure impulses of different intensity or pressure, the operator may determine which impulse is most desirable to produce the distinctive, recognizable and differentiable peaks *c* and *d*, allowing him to differentiate between echo from the tubing catcher and the echo from the fluid surface."

(Testimony of Cranford P. Walker.)

What does that mean by the "series of pressure impulses of different intensity of pressure"?

A. If you use an impulse which is of insufficient strength you may not get recognizable reflections from either of those objects. If it is too strong and the objects are close together they may actually overlap so that one blots out the other.

Q. Isn't there a time interval between them in the travel of that pressure impulse? [236]

A. Ordinarily there is. Frequently the catcher is set very close to the liner top, and if you don't use the right strength of impulse the two will merge and it will be difficult to tell whether it is one or two.

Q. Well, this says, "to differetniate between the echo from the tubing catcher and the echo from the fluid surface."

A. Well, the tubing catcher is frequently close to the fluid surface. It means exactly what it says, that if you don't use sufficient strength you may not get sufficient amplitude. If you use too much they may merge, may not separate from each other and they may be so distorted that they don't have any particular characteristics by which we could identify them.

Q. Mr. Walker, I am asking you what is meant by this statement where you say you observe the effects of a series of pressure impulses of different intensity or pressure. Does that mean you take a number of the charts before you can find out whether you have got what you want?

(Testimony of Cranford P. Walker.)

A. You don't have to take a picture of them. You can tell by watching a reflection on the ground glass. That beam which oscillates in response to the echoes can be focussed. One part of it is focussed on the ground glass on the top of the instrument; that is 38 in the drawing of patent 2,156,519, and the other part impinges upon the photographic record, and by watching that action of that beam on the ground glass we can determine fairly accurately whether we have the right strength of impulse or not. [237]

Q. Remember, we are talking about tubing catchers and fluid surfaces.

A. Yes.

Q. As I understand your testimony, it is that sometimes you can't distinguish between the two?

A. That is correct.

Q. My reading of that part that I have read from the patent, I understood you could then do something to your apparatus by means of which you could regulate it so you could get a difference between the two. Am I mistaken in that?

A. Are you referring to some previous testimony?

Q. No. I am referring to this part that I read to you from Patent 2,156,519, on page 4.

A. Yes, we can do something to it; that is, use the pressure impulse which gives the best reflections as shown on the ground glass.

Q. Then you mean you change around and final-

(Testimony of Cranford P. Walker.)

ly pick out an impulse which gives you the best results; is that correct? A. Yes.

The Court: Of the quantity of gas released into the annular spaces; is that right?

A. Yes, your Honor.

The Court: In other words, whether it is a little one or a big one? [238]

A. That is correct.

Mr. Graham: Q. Then, Mr. Walker, after you have made this adjustment for selection you do get peaks that are distinguishable from each other; is that correct?

A. That is the object of making the series of shots.

Q. And they are distinguishable from each other in the sense that you can distinguish, then, between the fluid level and the tube catcher by the shape of the wave?

A. Practically everything in the well, except the tubing catcher. The liner tops and the fluid levels give reflections which are the same, but a restriction like a tubing catcher, the reflection from that is not the same, because you have a pressure wave and a rarefaction immediately following one another.

Q. Then your answer to my question is "No"; is that correct?

A. I believe that is correct. It is not always possible to distinguish a tubing catcher reflection from some of the other reflections, but it does possess this characteristic by which we usually are able to identify it.

(Testimony of Cranford P. Walker.)

Q. Then if you select a proper impulse you can tell, from the shape of the wave, whether or not you had a tubing catcher or fluid level, is that correct?

A. Sometimes, yes. We don't do it so much by the shape of the wave, however, as we do by the records furnished by the oil companies.

Q. Then it is outside information? [239]

A. That helps.

Q. I hand you exhibits 19 and 20, which are blueprint records which you testified to. Now, are these made with Wyatt and Lehr apparatus?

A. They were made with the same elements, that is, a microphone, amplifier and a recorder, but not with the type of recorder shown in the Wyatt and Lehr patent; a more sensitive recorder than the type which they show in their patent.

The Court: What does theirs show? I have forgotten.

A. Theirs appears to show a typical, what we call a switchboard type of graphic voltmeter or ammeter that has a pen on it that makes an ink record on a moving strip of paper. In fact, they mention it in the patent as being a pen.

Mr. Graham: Q. Do you claim that this apparatus that you use is any different from the disclosure of the Wyatt and Lehr patent?

A. Well, the difference is, it is much more sensitive, much faster.

The Court: What is, yours?

(Testimony of Cranford P. Walker.)

A. The apparatus with which these two charts Exhibits 19 and 20 were made.

The Court. Yours is more sensitive?

A. This equipment with which these record were made. This is an electric oscillograph, whic has a much higher speed than the type which ap pears to be shown in the patent. [240]

Mr. Graham: Q. This difference that you hav pointed out is merely in the recording, the actua recording part of the apparatus; isn't that right

A. That is correct.

Q. In other words, it has an impulse chambe the same as Wyatt and Lehr, a microphone, an am plifier and a recorder? A. Yes.

Q. You do not mean to state or to imply tha with a carbon microphone, an oscillograph with camera recorder, such as you used to make thes graphs, Exhibits 19 and 20, it is not suitable t make a depth record on which tubing collars ap pear, do you?

A. I wasn't able to make it function that wa

Q. Then you cannot say that if that apparatu that you used for making Exhibits 19 and 20, wa properly operated, that it would not show tubin collars?

A. No, it would not.

Q. What is that?

A. I don't think it would.

Q. For what reason?

A. Well, I wasn't able to make it work tha way.

(Testimony of Cranford P. Walker.)

Q. You must know, Mr. Walker, why it didn't work so that you could get these reflections from the tubing collars.

A. Yes, for the reason that there are so many other oscillations that interferred with the tubing collars. For [241] one thing, we found that the length of well connection would completely obliterate tubing collar reflections in our subsequent experiments.

Q. Those oscillations are in there no matter what you use, aren't they?

A. Yes, there are some oscillations bound to occur in that pipe.

Q. Then it is merely a matter of adjusting the apparatus to make it work better?

A. No, I wouldn't say that entirely. You would have to have suitable equipment.

Q. Then is it your statement, Mr. Walker, that Wyatt and Lehr apparatus, properly constructed and operated, will not show the tubing collar reflections?

A. There would be a lot more required than what they show. You have interferences between casing joint reflections and tubing collar reflections, as shown by one of these exhibits you have here. The tubing joint reflections are more prominent than the casing joints, and in many cases you have reverberations in the connection between the instrument and the well, intermingling with those reflections from the casing joints and tubing collars, so that it would not necessarily be able to record

(Testimony of Cranford P. Walker.)

tubing collar reflections. I wasn't able to record them, and that was probably the reason; those three that I have mentioned. [242]

Q. You mean it did record them, but you could not distinguish them, or it didn't record them?

A. Well, they were so intermingled with all the other oscillations and echoes that they didn't come to the surface as separate echoes themselves.

Q. Do I understand that the plaintiffs in this case pay a royalty to Wyatt and Lehr under their patent? A. Yes.

Mr. Mattingly: If your Honor please, during the intermission the defendants wanted to use the blackboard here and suggested that I copy the material which appeared on it as illustrative of the witness' testimony this morning, and I would like to offer that in evidence as Plaintiff's Exhibit 29.

The Court: It may be admitted.

[Printer's Note: Plaintiffs' Exhibit No. 29 is set out in full in the Book of Exhibits.]

Mr. Mattingly: The Plaintiff rests, your Honor. [243]

Mr. Graham: I believe there is an offer before the Court of the Lehr deposition.

Mr. Mattingly: You are offering the deposition of Lehr only?

Mr. Graham: Yes.

The Court: Admitted.

Mr. Graham: Now, may I ask counsel if you have any objection to the Wyatt deposition?

Mr. Mattingly: I will make no objection to the introduction of the Wyatt deposition.

Mr. Graham: Then we will offer it in evidence.

The Court: It may be admitted.

Mr. Mattingly: May I have the exhibit numbers on those?

The Clerk: "M" and "N"; "L" already having been used. That will be "M" on the Wyatt and "N" on the Lehr, as they appear in this deposition.

Mr. Graham: Your Honor, there has been offered a book which has been marked for identification "K". This book contains the prior publications, and while those prior publications at the time the whole book was marked were mentioned, I would like to offer them separately in evidence, as they will be referred to by a witness; and I would like him to refer to them not only by name, but by exhibit number.

The Court: That is, separate exhibits?

Mr. Mattingly: I make no objection to the entry of these as being copies. [244]

The following publications were then offered and admitted in evidence.

Exhibit K-1—Article by Wilde and Moore, published June 30, 1931.

Exhibit K-2—Article by Stanley Gill, published April 4, 1932.

Exhibit K-3—Article by Hawthorn, published in 1933 in the transactions of the A. I. M. E.

Exhibit K-4—Article by Major W. S. Tucker,

HAROLD T. WYATT

a witness for defendant, testified as follows by deposition:

I live at 515 North Reeder Street, San Dimas, California. I am the Production Manager of the Shell Oil Company. I work for the Shell Oil Company here in Los Angeles. I have been subpoenaed to testify.

By Mr. Babcock:

Q. I show you what purports to be a printed copy of United States Letters Patent to Paul E. Lehr and Harold T. Wyatt, No. 2,047,978, granted July 21, 1936, on an application filed November 1st, 1933, for "Method and Apparatus for Measuring Well Depths", and ask you if you are the Harold T. Wyatt who was one of the patentees of this patent?

A. I am. Paul E. Lehr, referred to there, is the gentleman sitting in the room. I know Mr. Cranford P. Walker. He is present here in the room.

Q. Have any rights under the Lehr patent, that I just referred to, ever been given to Mr. Walker or any one associated with him?

A. The Depthograph Company have been licensed to operate under the Lehr and Wyatt patent. It is my understanding that the Depthograph Company is one of the plaintiffs here in suit and that it is a co-partnership between Mr. Walker and others.

Q. What kind of a license arrangement do you have with the Depthograph Company?

(Testimony of Harold T. Wyatt.)

A. I don't know; I can't answer that. I am in general [248] familiar with the terms of this contract.

Q. Do you receive any royalty at the present time from the Depthograph Company?

A. I do.

Q. Do you know about when you first entered into some kind of a contract, either oral or written, with the Depthograph Company or with Mr. Walker?

A. I don't remember just when it was. It was several years ago.

Q. It was after the issuance of the Lehr and Wyatt patent?

A. I don't remember.

I recall something about the history of the development of this invention of the Wyatt and Lehr patent. Lehr and myself were interested in studying well performance; we were interested in gathering data having to do with well performance. I was employed by Shell Oil Company, and Lehr was, too. We were interested in learning how to control and to improve the ability of a well to produce. And this method of locating fluid levels seemed to us to offer a useful means for understanding what was happening in oil wells. So we proceeded to develop our idea that fluid levels could be located from the ground level by the method outlined in the patent which you have quoted earlier.

I do not recall that this development started some time prior to the time we applied for a patent in

published in the Journal of the Royal Society of Arts, dated Friday, January 5, 1923.

Exhibit K-5—Article by Harold K. Ihrig, published in Oil and Gas Journal of October 17, 1935.

Exhibit K-6—Article by Christie, read at the Houston Meeting, October, 1931, entitled "Reservoir Pressures in the Hobbs Field, New Mexico."

Exhibit K-7—Article by Dale Nix, in the transactions of the A. I. M. E. of 1932, entitled "Determination and Application of Depth Pressures in the Yates Field."

Exhibit K-8—Article by Charles V. Millikan on "Bottom-hole Pressures in Oil Wells," published in 1931 in the A. I. M. E.

Exhibit K-9—Article by William Victor Vietti on "Density of Oil-Gas Columns from Oil Data" published in 1931 by the A. I. M. E.

[Printer's Note: Defendant's Exhibits K-1, K-2, K-3, K-4, K-5, K-8 and K-9 are set out in the Book of Exhibits.] [245]

The following prior patents were then offered and admitted in evidence:

O-1—Original patent of C. P. Walker, No. 2,161,733 granted June 6, 1939, of which the patent in suit Re. 21,383 is a reissue.

O-2—Patent of Batcheller, No. 602,422, granted April 19, 1898.

O-3—Patent of Fessenden, No. 1,217,585, granted February 27, 1917.

O-4—Patent of Fessenden, No. 1,240,328, granted September 18, 1917.

O-5—Patent of Tucker, No. 1,351,356, granted August 31, 1920.

O-6—Patent of Behm, No. 1,649,378, granted November 15, 1927.

O-7—Patent of Williams, No. 1,671,262, granted May 29, 1928.

O-8—Patent of Dorsey, No. 1,730,411, granted October 8, 1929.

O-9—Patent of Taylor, No. 1,847,636, granted March 1, 1932.

O-10—Patent of Smith, No. 2,008,934, granted July 23, 1935.

O-11—Patent of Gilmore, No. 2,021,774, granted November 19, 1935.

18—Patent of Lehr, et al, No. 2,047,974, [246] granted July 21, 1936.

O-12—Patent of Kunze, No. 2,116,523, granted May 10, 1938.

O-13—Patent of Scott, No. 2,173,426, granted September 19, 1939.

O-14—Patent of Halliburton, No. 2,201,311, grant May 21, 1940.

O-15—Photostatic copy of British patent to Tucker, No. 138,638, published March 4, 1920.

O-16—Photostatic copy of British patent to Tucker, No. 195,199, published March 29, 1923.

[Printer's Note: Defendant's Exhibits O-2, O-4, O-5, O-7, O-9, O-13 and O-14 are set out in the Book of Exhibits.] [247]

(Testimony of Harold T. Wyatt.)

1933. I can't [249] recall the time relationship between when we thought of it and when we applied for the patent. At about the time we applied for patent, we did experimentation in the field. We built and operated a tool like this of the patent.

Q. I will leave the patent here before you, so that you can refer to it. On page 1 of the patent 2,047,974, in the first column, starting at line 10, it says: "It has been attempted to measure the depth of wells by using a sound wave method in accordance with which a sound is made at the mouth of the well and then the elapsed time is measured for this sound to pass to the bottom of the well and be reflected back", and so on. Do you know whether that statement is true, that prior to the filing date of your application on November 1st, 1933, such attempts had been made to measure the depth of wells by the use of sound waves?

A. It is my recollection that attempts had been made by others.

Q. None had been made by you or Mr. Lehr?

A. I had made none.

Q. You don't know whether Mr. Lehr had or not? A. No.

Q. Were they by the Shell Oil Company, or what knowledge do you have as to these prior attempts?

A. My recollection is that the Shell Oil Company made no such attempt. My recollection is, and understanding at the time, [250] that the attempt was made by the Union Oil Company.

(Testimony of Harold T. Wyatt.)

Q. Whom, of the Union Oil Company, do you know?

A. I do not know.

Q. Just some rumor that you had heard of, or something like that? A. Yes.

Q. In this same paragraph of the patent it says that: "The sound wave method operates more perfectly in theory than in practice," and then gives some reasons for that statement. Is there any basis for that statement in the patent, as far as you know? A. I do not know.

Q. It says further: "In using the sound method referred to, perhaps the crookedness of the well hole has considerable to do with the dissipation of the energy of the sound, causing considerable reflection and partial absorption of the sound waves as they pass down the well and return." Was that statement just put in the patent for camouflage, or what was that put in there for?

A. The answer is, I don't remember why it was put in.

Q. You have no knowledge now as to whether that is so or not, that in using a sound wave method the crookedness of the hole has considerable to do with the dissipation of the energy, and so on?

A. No, I have no knowledge as to whether that is so. As [251] a matter of fact, I have had so little experience with the application that my recollection even as to what knowledge I had at the time is very vague. I am quite sure that I thought the

(Testimony of Harold T. Wyatt.)

whole—all the material contained in the patent, in the application, was true.

Q. What is your understanding of this statement in the patent, on page 1, column 2, beginning line 29, that: "Before proceeding to a detail description of this invention, it should be stated that it employs the impulse wave principle, and the impulse wave is not generated by sound, but is generated by causing a sudden change in pressure at the well head. This change in pressure may be occasioned by a sudden liberation of a sufficient quantity of gas at the well mouth to cause a sudden substantial increase of pressure or a sudden decrease"——

I understand that as it is written; I don't know how to, off-hand, paraphrase it or restate it.

Q. Well, you understand that statement that I just read to you, it means something to you?

A. Yes.

Q. Please explain what you understand to be the distinction between an impulse wave, or a pressure impulse wave, as distinguished from a sound wave?

A. I don't know whether I can distinguish between those two, I am afraid I can't. It has been a good many years since I gave that any thought or did any work on it. I would be very reluctant—in fact, I find it impossible to discuss the two.

[252]

Q. You mean to distinguish between the two, a pressure impulse wave and a sound wave?

A. I can't describe them, I am not able to.

(Testimony of Harold T. Wyatt.)

Q. Well, then this portion that I have just read doesn't mean anything to you, does it?

A. Yes, it means something to me.

Q. Well, it says that the impulse wave is not generated by sound; does that mean anything to you?

A. Yes; that means to me that the impulse wave is not generated by sound.

Q. Well, then, there must be some difference between an impulse wave and a sound wave, mustn't there?

A. The first thing I was trying to explain to you was that I couldn't explain the difference.

Q. Well, there is a difference, but you can't explain it; is that the idea?

A. That is the idea.

Q. On page 1 of the patent, in the first column, will you please read the paragraph beginning line 28 and ending in line 42, I guess it is?

A. (Witness peruses.)

Q. Does this paragraph refer to what you called, in one of your previous answers, well performance? A. Yes.

Q. And which I understand means the ability of the well [253] to produce oil?

A. Yes; oil, gas and water.

Q. The paragraph that you just read refers to pumping wells. What you were interested in at that time, was the performance of pumping wells?

A. Yes.

(Testimony of Harold T. Wyatt.)

Q. Will you explain how you intended to use this data, that you had obtained by the method and apparatus of this Lehr and Wyatt patent, in determining well performance or the ability of a pumping well to produce?

A. We wished to learn the relative position of the fluid level in the annular space between the tubing and casing, the position of the fluid level relative to the pump which was set in the well.

A. That is what we had in mind, in connection with the determination of fluid levels on pumping wells.

Q. Was it your intention to make these fluid level determinations while the pump was operating at different pumping levels?

A. I can't remember.

I am an experienced oil man. I have been in the employ of the Shell Oil Company for approximately seventeen years, and during that time have been engaged in oil field work, mostly production problems. I try to maintain a staff who keep up with the best methods of estimating the potential production of [254] a well, and things of that sort. I haven't done that myself for some years.

Q. At the time you and Mr. Lehr made this invention, you were particularly interested in using this tool as a means of helping you estimate the potential production of wells; is that correct?

A. No, I don't think that is correct; I can't remember that we did that. I can remember we were interested in producing wells to capacity—I

(Testimony of Harold T. Wyatt.)

should not say "we"—I can remember that I was interested in producing wells to capacity, and that I was interested in knowing whether wells were pumped off; in other words, I was interest in knowing when a well was pumping water, the liquid level had been pumped down to the inlet of the pump.

Q. You were familiar at that time with the use of what are called pressure bombs or pressure-recording devices for estimating bottom hole pressures in a pumping well?

A. No, sir, I was not familiar with them at that time.

Q. Then what does this mean here in the patent—I am quoting from the same paragraph I asked you to refer to and read—(reading) "The present method and apparatus affords means for determining well depths without the use of a sand line,". How was the well depth determined with a sand line? A. We used bailers.

Q. To determine what?

A. I used bailers to determine well depths and well [255] pressures.

Q. How could you determine a well pressure with a bailer?

A. I used a bailer which was in the form of a bomb which took a sample of the material in the well under the pressure which existed in the well, brought it to the surface, and observed the pressure.

Q. Well, then, you were familiar with means to determine well pressures, bottom hole pressures, by the use of a pressure bomb, were you not, at the time you filed this application?

(Testimony of Harold T. Wyatt.)

A. I think that we ought to have an understanding of the pressure bombs, perhaps that——

Q. Let me take that out of the question; let's put it this way: There were known ways of determining bottom hole pressure on November 1st, 1933?

A. Yes.

Q. And there were known ways and known methods and apparatus for determining well depths by the use of sound methods, were there not?

A. I don't know whether I understand the question.

Q. Well, I was paraphrasing the patent. By "sound method" apparently in this patent it refers to sound wave methods, where a sound is made at the mouth of the well, and then the elapsed time is measured for this sound wave to pass to the bottom of the well and be reflected to the mouth. [256]

A. My recollection is that I understood at the time that the sound method, as shown in quotations in this patent, could be used for the purpose of measuring well depths.

Q. You understood that the sound method that we have been talking about could be used to measure the surface of the liquid in a well between the tubing and the casing, did you not?

A. I understood that the method could be used, but that the results were unreliable, and I won't state the answer that way, because I don't think we should misunderstand, I wouldn't want my answer to be understood as meaning, or causing some one

(Testimony of Harold T. Wyatt.)

to think, that when I said a method could be used, that I implied it could be used successfully.

Q. Yes. And your answer would be the same as to the use of a sound method to get information in connection with pumping wells; is that correct?

A. That is correct.

Q. And that is, as I understand your testimony, that it had been tried and the results found not very reliable; is that correct?

A. That is what I understood.

Q. And you contemplated, when you filed your application for patent, to use your apparatus and method, as described in this patent, for getting the information in connection with pumping wells—the information I had reference to is—again I [257] am referring to the first column of page 1 of the patent, where at about line 36 it says, "it is also frequently necessary to have this information in connection with pumping wells".

A. We contemplated using this information in connection with the operation of pumping wells.

Q. And by "this information" you mean the information as to fluid levels obtained by operating the method and apparatus of this patent in the annular space between the tubing and the casing?

A. Yes.

Q. Did you intend to use the method and apparatus of this patent to determine the fluid level in the annular space between the tubing and casing, in connection with the procedure to determine or

(Testimony of Harold T. Wyatt.)

estimate bottom hole pressure, or pressure at the pump in the well?

A. I don't remember my intentions.

Q. I will adopt counsel's suggestion, and ask what you ever did with this method and apparatus, —I wish you would tell us what you did in the field with this method and apparatus, and first tell me, if you will, what you built; describe the apparatus that you actually built. Let's take it historically if you can recall, what is the first thing you ever built that would have anything to do with determining fluid levels in wells by the use of either sound or pressure impulses? [258]

A. My recollection is that we built a reservoir for gas under pressure; that we connected that to an impulse chamber; we connected the impulse chamber to the well-head through a quick-opening valve. We opened the valve and created an impulse into the well casing, and we observed the time required for that impulse to travel through the fluid level, or some obstruction in the well, and return to the surface.

Q. That would be exactly in accordance with Fig. 1 of your patent, as near as I can judge; is that correct? A. I think so.

Q. You had a little outlet at the mouth of the well, and it would determine the time it took for the impulse to travel down to something in the well and come back to that outlet, the time being measured from the opening of the quick-opening valve

(Testimony of Harold T. Wyatt.)

to the time a puff was felt at the outlet; is that correct? A. Yes, that is my recollection.

Q. Then did you ever proceed to build an apparatus like Fig. 2 of the patent, where a recorder was used? A. No.

Q. Never used a recorder of any kind?

A. I don't remember using one.

Q. Did you ever use any microphone of any kind?

A. Yes, I remember working with a microphone.

Q. What kind of a microphone?

A. I can't tell you. [259]

Q. Do you know anything about the radio art or sound-recording art? A. No, sir.

Q. In the patent here, on the drawing, Fig. 2, it says, "Microphone", and "Amplifier", and "Recorder". That was intended to be—as far as your understanding at that time, you contemplated just using whatever sound-recording that an engineer might specify there to record this puff; is that correct?

A. As I recollect, our purpose at the time was to provide a means for recognizing return of the impulse wave, a more sensitive means than the human ear and the human hand, and the timing mechanism we had, such as a stop-watch would permit.

Q. And you intended to use more or less just whatever conventional apparatus was available for that purpose?

A. No, I don't remember that. I remember that impulses were difficult to check, and we had in mind

(Testimony of Harold T. Wyatt.)

an arrangement that would amplify the impulses so that they could be more rapidly observed and recorded.

Q. Well, was it any part of your invention, this recording feature; that is, was it any invention on your part, or Mr. Lehr's part, in taking this impulse and writing it down on paper; was there any invention in that part of the system shown here?

[260]

Mr. Mattingly: Wait a moment; I object to that question, asking this witness what is or what is not an invention, and submit that the witness has not been qualified to do such—as a matter of fact, the Supreme Court has not yet determined that they are qualified to make such statement. If counsel wishes to ask the witness whether he considered it was an invention at that time, I have no objection to that.

Q. Consider the question in that light. Did you consider it any invention at that time to use what you have shown here in Fig. 2 of the patent to record the return of this impulse wave?

A. Well, I considered that we had invented the things which were set forth in this patent, and if this is set forth in the patent, then I am sure that I considered that I had invented it.

Q. Was Mr. Lehr a sound-recording expert or familiar with sound recording or the radio art or anything of that sort?

A. I don't know whether he was an expert or not. My frank opinion is, as one who is no judge, that he was not an expert.

(Testimony of Harold T. Wyatt.)

Q. You said that you never built any of this recording apparatus of Fig. 2. Did Mr. Lehr ever build any, to your knowledge?

A. Not to my knowledge

Q. Did anybody ever build any?

A. Not to my knowledge. [261]

Q. Mr. Walker, or anybody else?

A. I didn't know Mr. Walker at that time.

Mr. Mattingly: Is it understood that the previous two or three questions were directed to the time period immediately preceding the filing of the application, or immediately after the filing of the application?

Mr. Babcock: Well, I am talking about any time,—but of course it is limited to what this witness knows.

Q. You never heard of anybody building this apparatus of Fig. 2 of your patent?

A. I find it very difficult to answer that, because I know apparatus has been built—recording apparatus——

Q. And used in a system like that shown in Fig. 2 of your patent? A. I don't know.

Q. Have you got any records of actual work you did in the field?

A. No, I haven't any such records.

Q. Does Shell have any interest in this Lehr and Wyatt patent at the present time? A. Yes.

Q. And does Shell receive any royalty from Walker on this Lehr and Wyatt patent, or from the Depthograph Company?

(Testimony of Harold T. Wyatt.)

A. I don't know. [262]

Q. Is that covered by the contract between yourself and the Depthograph Company? A. Yes.

Q. Did you succeed in determining fluid levels—your experiments, or whatever they were, were they successful?

A. I don't know. Well, let me try to restate the question a little bit in my answer. Our impulses returned to the surface. I don't know what they went to or where they came from, but they came back from it. We sent them like the arrow shot into the air. I don't know where they went, but they came back.

Q. Did you use that information for any purpose at all? A. Yes.

Q. What did you use it for?

A. We used that information to give us ideas as to whether wells were producing to capacity. This was for Shell.

Q. I gather it wasn't done so much for an experimentation, to see whether this would work, as it was to try to determine fluid levels; is that correct?

A. We were trying to determine fluid levels, and we experimented in our effort to determine those fluid levels.

Q. Did you ever try it more than just this one time? A. Would you amplify the question?

Q. Well, how much did you use that system; did you just use it on one well, one time, or did you use it again?

(Testimony of Harold T. Wyatt.)

A. No, we used it—it was used on several wells.

[263]

Q. Well, you wouldn't run it for the second time if you didn't think you found out something of value on the first job, would you; in other words, this wasn't just something you tried and you got nothing of value, and you abandoned the idea—that wasn't it? A. No, the idea was not abandoned.

Q. It was a good tool, only you weren't so sure of your results; is that correct?

A. That is correct.

Q. Did you check with any fluid level determinations by other methods?

A. I can't remember definitely, but I have a hazy recollection that we checked it in wells where we were able to measure the fluid level also with a bomb.

Q. In that case there would not have been any tubing in the well? A. Yes.

Q. And do you recall how it checked out?

A. No, I don't.

Q. Would you explain further what you used these fluid level determinations for, how you applied them?

A. I recall we did this work—when we did this work on pumping wells, if we judged that the fluid level was above the pump, we then made changes in the pumping apparatus to attempt to lower the fluid level in the well. [264]

Q. You had a well with a pump in the tubing; is that correct? A. That is correct.

Q. You had a fluid level in the annular space

(Testimony of Harold T. Wyatt.)

between the tubing and the casing, that fluid level being somewhere above the pump?

A. Correct.

Q. And you determined where that fluid level was, to the best of your ability, by this impulse pressure wave method? A. That is correct.

Q. And then, of course, you knew then the distance from the fluid level to the pump?

A. Correct.

Q. And that was all you wanted to find out, was it, just that distance between the fluid level and the pump?

A. That was all we were able to find out.

Q. You didn't ever operate the pump at different rates, then, and see what happened to your fluid level?

A. I can't remember whether we did that or not. I can remember that we made changes in pump setting, changes in pump operation——

Q. Pumping rate, in other words, or rate of pumping. You don't recall whether you changed the rate of pumping to see what the fluid level would be?

A. By pumping operations I mean changing the arrangement [265] of the valves, or the length of the stroke, or something of that sort. We did those thing in an effort to improve the production from the well.

Q. Well, you did do those things, you did change the operating characteristics of the pump, did you, in response to these fluid level determinations that you made?

(Testimony of Harold T. Wyatt.)

A. When we discovered that the pump was not producing from the well all the liquid which it was apparently capable of producing, we then made changes in the pump.

Q. And you determined that by seeing what the fluid level was?

A. Yes. We judged that when the well wasn't pumped off that it was capable of producing more liquid.

Q. And then didn't you increase the production as response to those determinations?

A. Well sometimes we did, and sometimes we failed.

Q. Well, at least you tried to; you changed the pumping rate, the barrels per day.

A. Well, we always attempted to increase the pumping rate, the productivity of the well, the production of the liquid from the well.

Q. Well, then, you did change the barrels per day, then, or tried to? A. We tried to. [266]

Q. And then did you take any further fluid level determinations or measurements after you tried to change the production rate? A. I think so.

Q. What field were these wells in?

A. As I recall, we did our work in the Los Angeles Basin. There were several fields and, as I recall, we worked in several fields. I recall Signal Hill and Dominguez Hill. There may have been others. [267]

PAUL E. LEHR

a witness for the defendant, testified as follows by deposition:

Direct Examination

I live at 219 Monte Vista Drive, Bakersfield, California. My occupation is division superintendent of the San Joaquin Division of the Shell Oil Company, Incorporated. I am one of the patentees of United States Patent 2,047,974.

By Mr. Babcock: Q. In general do you agree with the testimony Wyatt gave about this patent this morning? A. I do.

Q. Do you have any knowledge as to whether the Shell Oil Company is receiving any royalty from Depthograph, either directly or indirectly, on this Lehr and Wyatt patent?

A. In this patent release which we secured from the company, we were given the patent to deal with outsiders, with the proviso that the Shell Oil Company would be able to use the instrument royalty-free. That is all the right they retained. In other words, there is another stipulation in there, that I am a little hazy on, that they call shop rights, which they have no intention of exercising.

Q. Your testimony, I understand, would be the same as Mr. Wyatt's with regard to the apparatus that you actually built back there some time ago and used to make fluid level measurements in wells?

A. Yes, substantially, it would be very close to the same [268] thing.

Q. You do not know of any records of anything that was done then?

(Testimony of Paul E. Lehr.)

A. There is only one record that was ever made, to my knowledge, and that is, we wrote to the company before ever a patent was filed, outlining our method of testing. In other words, we built this apparatus and we made just a few tests in the field with it, and we wrote it up in the form of a memorandum and sent it to the company, after we had built it. That report was written to Mr. Bagby, and he then transmitted it to Los Angeles. He was superintendent at Long Beach at that time.

Q. In this early work you did, you did connect the apparatus up to the annular space between the tubing and the casing, did you not?

A. Yes, we did.

Q. What kind of tubing did you use in the hole?

A. Some of it was upset and some of it was plain; most of it was two and a half inch, some of it was two; all of it had collars. The average length of that pipe was twenty-two feet.

Q. You have no knowledge of these supposed earlier attempts to measure the depth of wells by using sound wave methods, do you?

A. Only by rumor; nothing definite.

Q. Your testimony is just the same as Mr. Wyatt's in that connection? [269]

A. Very similar to it. As a matter of fact, I didn't hear of that myself until some time after we had made a successful test of our own. Now, Mr. Wyatt might have known of it previously, but I did not.

(Testimony of Paul E. Lehr.)

Q. Do you recall any of the circumstances about these rumors, who told you or where it was supposed to have been carried on, or by whom?

A. No, sir, I do not. I know where I first heard it, but I don't know who told me. It was in the Shell Company office, engineering office, at Long Beach, and the rumor was transmitted to me—I know I heard it from another Shell employee, but just who it was has slipped my mind. As best I can recall, I understood that the Union Oil Company had tried using two sirens, of different pitch, so that they would both run at a certain speed and beat, and from that beat they attempted to get a reflection of it, from allowing it to be put down into the well casing.

Q. You never heard of anybody shooting a gun to get the sound wave?

A. No, sir, I never knew of that until after we had made the patent application. As a matter of fact, I thought that we had invented it ourselves, because I tried the cartridge as well.

Q. In this early——

A. Yes, sir, before I had any knowledge of what had been [270] done by Mr. Batcheller. I tried this cartridge in lieu of my impulse chamber.

Q. And how did that work out?

A. To the best of my recollection, all I think I used was a 38 cartridge, fired directly into the annular space. This happened not to be an oil well at the time, because I was very afraid of it, I ran it in

(Testimony of Paul E. Lehr.)

a hole that had mud put in the lower part of it, and I knew it was gas-free.

Q. This was just a blank? A. A blank 38.

Q. Fired with a revolver?

A. No, sir. I don't know whether you are familiar with it or not, but these alemite guns, when they get stuck—they are used with a cartridge attachment—if you take and hit these things to unplug them—that is what I used, I put it right inside, as near as I could get it inside, and tried that. I didn't use any nipple, I just held it. I didn't connect it to the casing.

Q. Drilled a hole in the casing?

A. No; everything was open. Through the inlet side and the outlet side, you see, the two openings on the casing-head, it was covered over the top, I went in on one side and fired the cartridge, and there was no attempt at packing made; in other words, you know, it is almost like you had exploded it right over the top of a well head. [271]

Q. There was tubing in this well, though?

A. No, sir, not in that particular well.

Q. You only tried that once?

A. No, no, I tried it in another well, later on, that did have tubing in. Also it was mudded in the bottom, so it had no gas. And at both times the type of impulse I got—I got a return in the first well; the second well was deeper, and I got a very slight one, as a matter of fact, compared with the impulse chamber, three pounds pressure, you know,

(Testimony of Paul E. Lehr.)

when I released it here—gave much more of a return than a 38 cartridge.

Q. Well, I gather that you agree with these statements in the patent that in using a sound method the results are not satisfactory?

A. That was the basis for my statement.

Q. You said that was the basis for your statement; you mean the statement in the patent is based on your knowledge at the time?

A. That is correct.

Q. The statement I am referring to is on page 19 of the file history of the Lehr and Wyatt patent, particularly where it says, referring to Batcheller: "* * *it was not found satisfactory for the reason that there is not enough energy in the sound waves produced,". Did Lyon and Lyon get that idea from you? A. Yes, I think they did.

Q. Prior to the time when you applied for patent, did Lyon & Lyon make a preliminary examination of the art in the Patent [272] Office to see what novelty might be involved in your idea?

A. I don't remember that.

Q. If they did, you do not have any report?

A. No, sir, I have never had a report of that, no.

Q. How long have you been in the oil business?

A. Sixteen years and three months with the Shell Oil Company. I have been with Shell since I left the University, with the exception of two months I worked for General Petroleum. I am in the production end of the business. I have not always been. At the time Mr. Wyatt and I collaborated on

(Testimony of Paul E. Lehr.)

this, Mr. Wyatt was production foreman and I was a field engineer. However, in the production department.

Q. As to this Fig. 2 of the Lehr patent, your testimony would be like Wyatt's as to what would be used for recording these pressure impulse reflections?

A. Yes, sir. We appreciated, from our other method, and checking with some bailer runs that Mr. Wyatt referred to, in order to find how our velocity time was, to check the depth we would measure with a bailer, and we appreciated that the human element introduced a serious error into the method, and that a more accurate timing was necessary to secure greater accuracy, which is the basis for this recorder.

Q. And you knew that there were devices on the market which would record that a lot better than you were able to do mentally, or count the time mentally? [273]

A. Manually.

Q. You never made the apparatus of Fig. 2 of the patent?

A. Not of Fig. 2 of the patent, no sir.

Q. Did you ever make any recorder at all?

A. No recorder of this type shown in Fig. 2. There was a friend of mine who had something like a little bit of address system, with a microphone, in which an ammeter would jump in response to the sound, which we tried. But it gave no record; in other words, you would just look at

(Testimony of Paul E. Lehr.)

it. There was definitely a microphone, and there was this—I think an ammeter, that would jump—I recall quite well of holding this thing to my stomach, and you would growl, and it would indicate on the ammeter.

Q. Had an amplifier, no doubt?

A. Undoubtedly an amplifier.

Q. That would have been something like this Fig. 2, if you left the recorder off and put just a visual indicating meter at that place instead of the recorder?

A. Do you mean by that that we would not have a strip chart to correlate time?

Q. Yes; you didn't have that, did you?

A. No, we did not.

Q. Well, you had a microphone, an amplifier, and an indicator; that is what you had? [274]

A. That is right.

Q. And you tried that out on a well?

A. Yes, sir.

Q. How did it work? A. Fine.

Q. When did you do that?

A. I believe that was after we filed the patent. I am not sure whether it was shortly before or just shortly after. It was right in there. Right at that time.

Q. Where did you put the microphone?

A. At No. 9 in Fig. No. 1.

Q. Right at that pipe?

A. Yes; we laid the microphone in there. As I recall it it was a little large, and instead of run-

(Testimony of Paul E. Lehr.)

ning the pipe out at a steady diameter, we swedged it up just a little bit so we could lay it in there. The microphone, after being used several times in the presence of gasoline vapors, became less and less sensitive.

Q. And do you know what kind of a microphone that was?

A. No, sir. Let me say this, it was a carbon type of microphone, I do remember that—I don't know whether that is of any account or not, but this was the same type of microphone that we have in the transmitter on the telephone. The microphone was supplied by Harold Nichol. He is in charge of the meter shop for the production department of the Shell Oil Company. In [275] other words, he services drilling instruments, pressure recorders, and all types of that sort of equipment. We were just getting started in the other place.

Q. How many wells did you have this microphone on?

A. To the best of my knowledge, only one.

Q. How deep was it to the fluid level, do you know, about?

A. In those days we tried them pretty shallow, I would say it was less than 3500 feet.

Q. You had an impulse chamber, and a source of fluid pressure, like that shown in Fig. 1 of the patent.

A. Yes, sir, and a quick-opening valve. First we had our source of pressure gas or pressure fluid, as shown in Fig. 1. We filled the impulse cham-

(Testimony of Paul E. Lehr.)

ber to the pressure we thought was about right, I imagine it was between thirty and fifty pounds; then we had that pressure there trapped, we shut valve No. 3, opened the quick-opening valve No. 6, and observed the ammeter. Then when the echo came back, we observed it flicker again—and I forgot to mention that we started our stop-watch at the time we opened the quick-opening valve, got it just the same as if we were holding our hand and watching the impulse.

Q. Did the needle flicker any?

A. Yes, sir.

Q. What do you think that was due to?

A. The echo coming back. [276]

Q. Well, I mean, in between the time that you opened the quick-opening valve and the time you stopped your stop-watch, as indicative of the reflection from the fluid level, did the needle flicker in between there any?

A. Well, as I recall, the needle got quite a bump on the first one, and the time was sufficient, that it quieted down by the time the echo came back.

Q. Well, there were some flickers then in between the first shot and the final reflection?

A. Rather than saying it was in between, I would say it was a rather prolonged disturbance from the initial shot.

Q. You don't think it could have been due to reflections from minor obstructions in the well?

A. In the particular well we were in, as I recall, there was none that we observed.

(Testimony of Paul E. Lehr.)

Q. There was tubing?

A. There was tubing.

Q. And the tubing had collars?

A. Yes, sir, but those did not show on this microphone arrangement that we had.

Q. How do you know?

A. I could not tell it, I had absolutely no knowledge of it.

Q. But the needle was apparently vibrating, from what you said? [277]

A. Just initially. I am afraid we didn't have as sensitive a microphone, perhaps, as you have in mind. It jumped very much at first. Then it went clear back, and I could see no movement of it until we had the fluid reflection.

Q. Do you recall the circumstances relating to the transfer of some rights under this patent to Mr. Walker or the Depthograph Company.

A. Yes, I think I recall some of the general things.

Q. Did you disclose to him all that you have been telling us here this morning?

A. I don't believe I ever mentioned to Mr. Walker about the use of this microphone. As far as my knowledge of imparting information to Mr. Walker is concerned, I had only shown him Fig. 1 in operation.

Q. Was the transfer of these rights made after the patent issued, or before?

A. I don't remember.

(Testimony of Paul E. Lehr.)

Q. Was there any other agreement, either oral or written, other than this one—I gather that you got a final written agreement, did you?

A. Yes.

Q. Was there any other prior agreement or anything of that kind?

A. There was nothing in writing. Mr. Wyatt is much more [278] familiar with that phase of it than I. I was not in Los Angeles at that time.

Q. He did the negotiating?

A. Most of it, yes, sir.

Q. For both of you?

A. Yes, sir. I was familiar with it after it was done, but meetings and things of that type, I was not familiar with.

Cross Examination

By Mr. Mattingly:

Q. At the time you tried out this device with the microphone, as you have described it here, you stated that there was quite a big bump at first, and then the needle of the meter later flickered as a result of receiving the echo from the fluid level. Do I understand you to mean, by that initial or first big bump, that that occurred at the time you opened the quick-opening valve to let the impulse go into the well? A. Yes, sir.

Q. And the second flicker of the needle was caused by the echo received back from the fluid surface? A. That is correct. [279]

CLERK'S COPY.
Vol. II
TRANSCRIPT OF RECORD
(Pages 273 to 586)

Supreme Court of the United States

OCTOBER TERM, 1945

No. ~~290~~ 24

HALLIBURTON OIL WELL CEMENTING COMPANY,
PETITIONER,

vs.

CRANFORD P. WALKER AND CRANFORD P. WALKER, D. A. WALKER, ET AL., DOING BUSINESS AS DEPTHOGRAPH COMPANY, COPARTNERSHIP

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT

PETITION FOR CERTIORARI FILED AUGUST 2, 1945.

CERTIORARI GRANTED OCTOBER 15, 1945.

No. 10513

United States
Circuit Court of Appeals
For the Ninth Circuit.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Appellant,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Appellees.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Appellants,

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Appellee.

Transcript of Record

In Five Volumes
VOLUME II
Pages 273 to 586

Upon Appeals from the District Court of the United States for the Southern District of California, Central Division

Rotary Colorprint, 590 Folsom St., San Francisco

RANDOLPH W. CORNES

a witness called by and on behalf of the defendant, testified as follows:

My address is 305½ North Twelfth Street, Duncan, Oklahoma. I am an engineer with Halliburton Oil Well Cementing Company. I am in charge of the Echo-Meter operations of the Halliburton Oil Well Cementing Company. I have available here in the court room an Echo-Meter apparatus as built and used by the Halliburton Oil Well Cementing Company.

The Court: What is the rubber hose?

A. That rubber hose is just used as a substitute for the oil well. This equipment here is the unit which is attached onto the well normally, and the hose takes the place of the well. This branch of the unit comprises the gun which initiates the sound which goes down the well.

The Court: Does that go down the well, or go into the chamber adjacent the well?

A. This part of the apparatus is connected directly into the top of the well, and the sound comes from the gun, and goes into the well, down through the annular space into the well.

The Court: It does not appear to be that way from the diagram, according to the answers to the interrogatories it was attached to 8; then, under the supplement to the answers, there was a valve at 8, which is 8-A, so it is attached to a valve or pipe which is attached to the well.

A. The unit is attached into the valve, into the

(Testimony of Randolph W. Cornes.)

well. [280] The valve is not necessarily a part of the equipment.

The Court: There is either a valve or an elbow there?

A. Yes, or it can be connected straight into the well. There is a pipe fitting there with which you can screw it into the casing, and the equipment which we attach is attached to that pipe fitting. The shot is fired into that unit. The shot travels through the pipe fitting, through the L down into the well, and down that annular space I described.

The Court: So the shot is really fired into a chamber which appears to be a V-shape or elbow?

A. That elbow is slightly different from this branch, which comes this way. The other is off at an angle.

The Court: Is that put into the top of the casing, the elbow, in a V shape, like that, or is one of those vertical, like you have in the drawing?

A. That unit is attached which comes off the V-shape.

The Court: You have different types of unit?

A. There is no essential difference there. That was made for convenience to lighten the unit. The shot is loaded into this electrically fired gun, and it is fired by releasing the mechanism in the gun. As the shot is fired it goes down through this pipe fitting, and on into the well, and the reflections that come back from the well come through the pipe fitting unit, back through the opposite branch of this Y, through the adjustable valve and into the

(Testimony of Randolph W. Cornes.)

microphone, which is in the pipe fitting [281] or union of that branch of the Y.

By Mr. Babcock: What is the red chamber with a valve above the union which you said contained the microphone?

A. That is what is called the surge chamber, for the sound.

The Court: From here, the place where you fired the shot has a handle out to the side?

A. Yes. The handle is merely for removing that gun, to allow the operator to get a good hold on the gun when he puts the shot in here. This is the firing mechanism, such as the breech on a gun.

Mr. Babcock: Q. What is the purpose of having this coil of rubber hose attached to the bottom of the unit?

A. That is merely to simulate an oil well in demonstrating the equipment. It is approximately 100 feet long.

The Court: What is that open valve for on the right arm in the surge chamber?

A. That is for attaching a pressure gauge in case there is pressure in the well, and you want to read the pressure. That valve is closed now.

Mr. Babcock: Q. Now please explain the apparatus in the wooden box, which you have here in the courtroom.

A. This apparatus consists of an electrical amplifier which is connected through a cable to the microphone in the casinghead unit. The signal from the microphone comes into the amplifier,

(Testimony of Randolph W. Cornes.)

and is applied with sufficient intensity to run this [282] recorder in the back part of the box. The electrical signals from the amplifier cause this cylinder here, the cylinder which the paper travels across, to move back and forth, and as the paper is driven across the cylinder by the motor driving the recorder, and is driven electrically from the amplifier back and forth, the record is traced on that tape in that manner.

The Court: The thing that jiggles is not the pen; it is the paper?

A. The pen is stationary. The paper moves back and forth crosswise with the signal. The constant speed from the motor drives the paper lengthwise.

Mr. Babcock: Q. Will you name the electrical elements involved in this apparatus in the box in transmitting the signal from the microphone to the recorder,—I mean what elements are necessary to cause that recorder to make a record on the tape in response to signals from the microphone.

A. In the first place, there is a battery in here, used to energize and pass current through the microphone. That current heats the microphone, and the signal which comes back from the well cools that microphone wire; that is, each signal cools the wire slightly as it passes the microphone. That cooling of the wire changes the wire's resistance, which changes the current flow through that circuit, and introduces the signal into the amplifier.

(Testimony of Randolph W. Cornes.)

The amplifier is made up of radio tubes [283] similar to an ordinary amplifying system. The signal goes through that amplifier, and comes out with sufficient intensity to have energy enough to move this cylinder here. There is an electrical filter in there, operated by this center control. In the position it is in now, the filter is turned off; disconnected entirely from the circuit.

In the Echo-Meter operations of the Halliburton Oil Well Cementing Company the filter is not always used. This is the same apparatus that we had out in the field the other day at Dominguez, when you invited counsel and Mr. Walker and some of the others for the plaintiffs to witness defendant's operations.

Q. Will you please demonstrate to the court, how this device operates to make a record of the firing of the shot, and of an echo therefrom?

As you manipulate the apparatus in any way, state what you are doing.

A. I first load the gun with a small 22 blank shell, which is of sufficient size for this demonstration. The gun is loaded; then cocked by pulling back this small handle. I just cocked the gun. This is an electrically fired gun.

The Court: Is that gas in that hose?

A. Just air. It operates the same as air or gas in an oil well; it will make no difference. [284]

Mr. Babcock: Q. Is the butterfly valve beneath the microphone open or closed?

(Testimony of Randolph W. Cornes.)

A. It is slightly open. It makes very little difference for the purpose of the demonstration how it is. There is a sufficient opening there. When the gun is loaded, this switch is turned on on the amplifier here. First, just in a position which heats up the tube; then in the second position, the current passing through the battery into the microphone, in the third position, turns on the amplifier. The final position starts the tape going, and pressing this button fires the gun.

Q. Is the gun now fired?

A. The gun is fired. When it clicked, at the time I pushed the button, it was fired, and gave us this tape.

Mr. Babcock: I offer in evidence this tape as Defendant's Exhibit C, this being a tape made with the apparatus demonstrated in court.

[Printer's Note: Defendant's Exhibit C is set out in full in the Book of Exhibits.]

The Court: That hose is closed on one end, is it? A. Yes, it is, your Honor.

Mr. Babcock: There appear to be a number of deflections or wiggles in the line drawn on the tape. Explain what those are.

The Court: Which is the bottom, and which is the top of the tape? Where is the shot fired? Indicate that.

A. I will mark it on the tape. This first line of reflection is where the shot went off. [285]

The Court: Which way does the tape travel? Indicate that by an arrow.

(Testimony of Randolph W. Cornes.)

A. The tape is traveling in the machine so that this large reflection is the first one to pass through. This smaller movement of the pen here is the first reflection of the sound coming in the hose. I will mark this point "first reflection".

The Court: At the end of the hose?

A. I will mark it "end of the hose". The sound is then traveling from the gun to the end of the hose, and back to the microphone, where it is recorded here. Then a similar reflection——

The Court: That has traveled 200 feet, the sound?

A. Yes, it has; then the small reflection back. The sound traveled through the hose and back to the microphone at the end, which would give this end of hose reflection here.

The Court: That is the end again?

A. The end again.

The Court: How many times did it go through there before it stopped?

A. Because of the small size of the hose it dimmed out quite rapidly, and only the two reflections show up.

Mr. Babcock: Q. In between the deflection indicating when the shot was fired and that which indicates when the echo returned from the end of the hose are there any waves?

A. There is a small wave there indicating a coupling in the hose about half way through the length of the hose. I will [286] mark that on the chart as the coupling echo.

(Testimony of Randolph W. Cornes.)

Q. In this apparatus which you have just demonstrated, did you use the filter when making that chart? A. No, I did not.

Q. It was not in the circuit at all?

A. No.

The Court: Between the end of the hose, the first end of the hose, and the end of the hose No. 2, there are a lot of jiggles. What are they? They all seem to be about regular.

A. I don't think there is anything particularly that they could be attributed to. There is no definite reflection point in there.

On September 29, 1942, I demonstrated this apparatus on an oil well at Dominguez, California, for Mr. Walker and counsel for plaintiff.

This apparatus here in court, except for the hose, is one of the commercial apparatuses used by the defendant.

Mr. Babcock: I offer this print at Defendant's Exhibit D.

[Printer's Note: Defendant's Exhibit D is set out in full in the Book of Exhibits.]

The Court: Those are prints of well graphs, are they?

Mr. Babcock: Made to demonstrate defendant's apparatus to the plaintiff, on the Union Oil Company Well Callender No. 79, Dominguez field, on September 29, 1942.

Q. This chart Exhibit D appears to have six graphs. Will [287] you please explain what each of those is?

(Testimony of Randolph W. Cornes.)

A. I will start at the right hand side. Chart No. 1 is a record made on this well using the regular equipment which we use on a commercial operation, using a ten-gauge blank shell as the source of sound, and no filter. No. 2 is made in the same manner, except that the filter was used to get that record. Record No. 3 is the same as record No. 1, that is, with no filter; but with a .38 blank cartridge instead of a ten-gauge which was used in No. 1. No. 4 is the same as No. 3, that is, a .38 blank, but the filter was used. It is marked "filter set at 3.7" which is the same setting which was used on record No. 2.

The Court: What does that mean on that graph No. 4, "Valve closed"?

A. The small valve, butterfly valve near the microphone was closed when that shot was made, and it was also closed when the two pervious shots were made. with a filter and without, on charts 2 and 3. On chart No. 5, the .38 blank was used and the filter was used, but the filter was set at 6.0 rather than being set at 3.7. Then on record No. 6—well, let's go right back to record No. 5. The amplification setting on the amplifier was set at 20 and increased to 35 near the end of the record. Then record No. 6 is of the same type, except the amplification was a little higher, starting at 22 and going as high as 46, both using the filter set at 6.0. [288]

Q. Let us go back. In chart No. 2 where was the filter set? A. Set at 3.7.

(Testimony of Randolph W. Cornes.)

Q. And why was it set at that point?

A. Record No. 1 was taken first, with no filter, and then ten collars—you can see the ten collars marked off about 6 inches from the top of the record of chart 1. There is two marks on it. The length between those two marks, the length of those ten collar reflections was measured with a scale and found to be 3.7 centimeters. Then the filter knob on the instrument was turned to 3.7 to correspond to that reading, which turns the filter on, connected with the end of the circuit and automatically set it at the right value.

The Court: You measured the distance between ten tubing collars on chart No. 1?

A. That is right.

Q. The distance between the first one to the end.

A. Yes, the distance between the two marks.

Q. What relation has that with the amount of electrical energy in the filter?

A. That adjusted the filter to the proper setting or frequency with which these echoes came back. The filter is calibrated in that manner to save referring to our frequency and using a calibration chart of some kind.

Q. That is, the ratio begins with 10, is that it, so you counted 10 of these and this was 3.7? [289]

A. That is right.

Q. And whatever distance it takes to count 10 echoes, why, that is where you set your filter?

(Testimony of Randolph W. Cornes.)

A. That is right, your Honor. It could be adjusted for some other value, but 10 is a convenient count-off, so that is always used.

Mr. Babcock: Q. So that in setting the filter to make run on chart 2, you set the filter in such position as to be particularly responsive to the length of tape between the ten tubing collar reflections on tape No. 1?

A. Yes.

Q. Now, in charts 5 and 6, what was the purpose in setting the filter off at some other value?

A. That was done to see whether it would affect the appearance of the record any if the filter was set at the improper value.

Q. Settings on charts 5 and 6 were for improper values, according to the data obtained on chart 1?

A. Yes, almost double what it should have been.

The Court: Well, wouldn't there have been a difference on a .38 shell from what there was on a ten-gauge?

A. No, your Honor. The spacing of the collars there is the same regardless of the source of the sound used. The sound would travel through the gas at the same speed regardless of the amount of energy. [290]

Mr. Babcock: Q. What relation does the amplification bear to the kind of shell used in making the sound?

A. With the smaller shell it usually takes more amplification to get the same type of record.

(Testimony of Randolph W. Cornes.)

The Court: Of the 10 there, isn't that right in the middle? Wouldn't five of those be just before the fluid level and five of them back?

A. No. The fluid level, your Honor, is about two inches farther down on the record, that larger reflection there.

Q. There is the fluid level, but the sound don't record on this until it hits the top of the casing, does it, until it hits the microphone?

A. After the shot has been fired the sound starts down the well and a small fraction of it is reflected from the first collar. That small fraction comes back up to the surface and gives this first kick. Then the sound travels on down to the second joint and comes back up to the surface to give the second kick, and so on down until it hits the fluid level and comes back up to the surface and is recorded in that large kick, large reflection.

Q. The number of these jiggles, then, is the number of collars from the top of the fluid level?

A. That is right.

Q. And is not twice the number of collars?

A. No; because the sound has passed each one and a small [291] part reflects it back up, so the small jiggle just ahead of the fluid reflection is the collar just above the fluid surface.

Q. Why is it bigger?

A. Why is the fluid reflection larger?

Q. No; the collar above the fluid reflection on that No. 1 column there. It is bigger and the next

(Testimony of Randolph W. Cornes.)

one is smaller. It does not follow the straight line, but a little ways here, and it is eccentric.

A. That is due probably partially to noise and disturbances in the well, and partially to the operator's control of the amplitude, that is, the amplitude is increased throughout the record and it may not be increased at a uniform rate. In other words, it may have been increased a little bit more in relation to the amount of sound arriving in some case and giving a larger reflection, and others giving a smaller.

Q. Well, that way, then, the operator here might turn the juice on and get an amplification of a collar which would indicate a large jerk in the line?

A. That is right.

Q. Which otherwise would be taken to mean some material which would reflect an echo, such as a tubing catcher or artificial element placed in there to reflect sound, is that correct?

A. It is. It takes a little experience to manipulate that control properly so you would get it.

Q. So this is not automatic; you don't set this in the [292] beginning and let it do it itself?

A. That is right.

Mr. Babcock: Q. In chart 1 and chart 2 of this exhibit D, graphs 1 and 2, tubing collar reflections do appear, do they not? A. That is right.

Q. The same is true of all the other graphs of this exhibit? A. Yes.

Q. To bring out the relation between when a

(Testimony of Randolph W. Cornes.)

filter is used and when a filter is not, would you compare graphs 3 and 4, for example?

A. There is a slight difference between 3 and 4. For instance, about three-quarters of the way down the record, the collars where the filter is used appear to be somewhat more uniform there. That is the essential difference there. Chart No. 3 has slightly more amplification than No. 4, but that is not a function of the filter.

Q. Can the tubing collars be counted in each case? A. They can.

Q. Can they even be counted with the filter set in the wrong position as in charts 5 and 6?

A. Most of them can. There are several places there which might be difficult to count accurately, but a large number of them could be counted.

The Court: How far down is it?

A. Do you have one of those records which is counted? [293] Well, I will count one of these. We will start out with No. 1, which has a fraction over 65 joints, tubing collar joints, above the fluid, if I counted correctly there.

The Court: Well, how deep is it?

A. I don't know the exact length of the tubing, but assuming the tubing is 30 feet, which would be pretty close, it would be 1,956 feet from the surface of the fluid, that is, 30 times 65.2, that would be 1,956.

Mr. Babcock: If the court please, I would like the witness to mark on that exhibit the fluid levels on each of the graphs—fluid level reflections on

(Testimony of Randolph W. Cornes.)

each of them. The witness has written "Fluid reflection" on each of the graphs on Exhibit D.

The Court: These irregularities such as in column No. 4 below where you have marked one fluid reflection, about 30 spaces down, is that due to a greater impulse of electricity in turning the knob higher, or is that due to some resonance in the well? Take on No. 6 over here, it is very irregular.

A. That is partially due to turning the amplitude control probably, and also due to the filter setting being so much in error.

Q. It is partially due probably?

A. Well, it is a combination of those factors, and, perhaps, some others coming in there.

Q. Then it isn't anything in the well that causes an echo to be greater and make those marks?

A. Well, there are cases in wells where you may get [294] stronger reflections from one depth than from another, that is, stronger reflection from a deeper section than you will a shallower.

Q. This is a recurrence of the record at the top in No. 4. That is pretty regular all the way through to the fluid reflection, and then below the fluid reflection it gets very small and very large, and very small and large, and then practically disappears into a straight line up about half an inch, and then up again, indicates some irregularities.

A. I believe that is principally due to the manipulation of the control.

The Court: I see.

(Testimony of Randolph W. Cornes.)

Mr. Babcock: Q. What size cartridge or shots does the defendant use commercially in its gun?

A. 10-gauge shells and .38 shells; 10-gauge blanks and .38 caliber blanks.

Q. Would one of them be satisfactory for all wells?

A. The 10-gauge shell should be satisfactory in all cases.

Q. Why do you sometimes use the .38?

A. Principally because it is less expensive.

Q. Do you have a hot-wire microphone here?

A. I have one in my pocket. Here is one here.

Mr. Babcock: Let us give that an exhibit number. I offer into evidence the hot-wire microphone produced by the witness as Defendant's Exhibit E.

[295]

The Court: The wires are not hot all the time, are they?

A. No; not unless they are in the instrument, and then they don't get very hot.

Q. They have to be activated by electricity, don't they?

A. Yes, they do. They are heated electrically the same as a lamp or flatiron. The device consists simply of a disc with a grid. The disc fits in the coupling in the casinghead unit. That is the small tungsten wire wound across there on both sides. It starts on one side, goes back and forth, then across on the other side. That small wire is the wire which is heated by the electric current,

(Testimony of Randolph W. Cornes.)

and being so small, a very small sound or impulse of gas will cool that wire off, because the electrical characteristics of it change and gives a signal.

Q. How is it heated? Through these same wires there?

A. Yes. And on either side what you are looking at is a little terminal box and those are connected electrically to terminals inside of the pipe.

Q. Are these connected through these little screws?

A. The wire is connected through one end to one side, and the other end to the other side. The end of the wire is under the little screw. The end of the wire comes under the screw and the screw tightens down on it, and the connection is made by —the disc slips over a couple of rods there. The rods slip through those small round holes there, and is held in [296] place by two small knobs so it will make contact.

Q. Does this reproduce sound?

A. It picks up sound which moves through or causes changes in the heat in the wires. The sound represents the movement of the gas, movement of air or gas, and that movement of the gas cools the microphone—cools the wires, and that cooling is what causes the change in electrical characteristics of the wire. The electrical variations caused by that microphone are amplified.

I was educated at the University of California at Los Angeles and the University of California,

(Testimony of Randolph W. Cornes.)

majoring in physics. I have a degree of A.B. granted by the University of California.

I am familiar with the patent to Paul E. Lehr and Harold J. Wyatt No. 2,047,974, granted July 21, 1936 on an application filed November 1, 1933. I have built an apparatus in accordance with the disclosure of Figure 2 of that patent. Figure 2 of that patent shows an impulse chamber. That is reference No. 4. Also with a supply of gas No. 1 connected to that impulse chamber by this pipe No. 2. There is a pressure gauge on the impulse chamber No. 5, that is connected into the casing of the well No. 14. The well contains tubing also, No. 8, and on the opposite side of the well is connected to a small fitting No. 13, the microphone No. 15. That microphone is connected to an amplifier No. 18, and then by wires No. 17 to a recording mechanism, apparently a pen recorder. This stylus is No. 22. [297]

Mr. Babcock: Q. How did you build the apparatus which you say you built in accordance with the Figure 2 of this Lehr patent?

A. We built an impulse chamber similar to No. 4, using a piece of 4-inch pipe approximately 30 inches long; and then for a microphone we used a simple carbon microphone from the telephone, connected into the amplifier which you see on the floor there, the regular amplifier and recording mechanism which we use on commercial jobs. I have here in the courtroom the pressure cylinder that I used.

(Testimony of Randolph W. Cornes.)

Q. Will you please demonstrate that or just show it to the court?

A. This is the impulse chamber here, consisting of the chamber pipe, and then the valve mechanism for quickly releasing the gas in the chamber into the well, giving impulse. This large valve is the quick-opening top valve here. This end of the valve was attached onto the well and this small valve here was used for putting gas into the chamber under pressure.

Q. Did you ever connect this apparatus up to an oil well and use it to determine well depths of fluid or obstructions?

A. We used it on a test well in Duncan to make these measurements. The impulse chamber 4 was connected into the casing as is shown in Figure 2 in the drawings of the patent. On the opposite side, as shown in that drawing, was connected a [298] carbon microphone.

Q. Did you ever use any other kind of microphone in this apparatus?

A. Yes. We used the hot-wire microphone, the same as we use in our commercial work.

Q. Did the test well have tubing in it?

A. Yes; it did.

Q. How deep was the test well?

A. Approximately 600 feet. It was not actually producing oil. It was one which was drilled for testing various types of equipment, but it was in construction the same as an oil well.

(Testimony of Randolph W. Cornes.)

Q. I hand the witness two graphs and ask him to explain what they are, if he can.

A. They are records made on this well, using the impulse chamber, and the one marked "regular set-up" was used with the hot-wire microphone; the other one, marked "No. 3 microphone" was used with an impulse chamber and a carbon microphone. This marked "no filter", the filter was not used on either one of those records. These were made with a pressure impulse chamber. They were made with apparatus constructed in accordance with Figure 2 of the Lehr patent, and they were tests that I ran myself.

Mr. Babcock: I offer these into evidence as Defendant's Exhibits F and G.

[Printer's Note: Defendant's Exhibits F and G are set out in full in the Book of Exhibits.]

The Court: F will be the hot-wire microphone recording on [299] this, and G will be the carbon microphone recording.

Mr. Babcock: F is the graph made with the Wyatt and Lehr apparatus.

The Court: It is the hot-wire recording, distinguished from the carbon microphone recording.

Mr. Babcock: Who else was present at the well when you made these tests, Exhibits F and G?

A Dr. Mackeown was present.

On these graphs F and G, echoes from tubing collars appear in both of them.

Q. I am handing the witness Exhibits F and G,

(Testimony of Randolph W. Cornes.)

and ask him to mark on each of these the point indicated on each as to when the quick-opening valve was opened to allow the gas from the pressure impulse cylinder to enter the well. The exhibits are marked "Valve opened" at the point at which the valve was opened to release the impulse of gas. I have put an arrow at the point designated.

Q. Please place on each of these exhibits a large arrow indicating which way the paper was traveling in making these charts.

A. The charts are marked with a large arrow indicating the direction in which the paper traveled, and the arrow is labeled "Paper travel".

Q. Will you also mark each of these exhibits at the point [300] where the fluid level echo returned from the well?

A. I have done so and marked it "Fluid level echo".

Q. Will you please mark on each of these exhibits F and G, as by means of a bracket, where the echoes from tubing collars appear?

A. I have done this and marked the bracket "Tubing collar echoes".

Q. Do you recall what the conditions at the test well were when you made these graphs Exhibits F and G? First, do you know what size casing and tubing?

A. The casing was approximately of 5 inches inside diameter and the tubing was standard 2-inch tubing, the joints about 30 feet long.

(Testimony of Randolph W. Cornes.)

Q. Did the well have fluid in it?

A. Yes; the well had fluid at the bottom.

Q. As far as fluid level determinations are concerned, were the conditions the same as exist in an ordinary oil well? A. Yes, they were.

Q. When you made these charts, Exhibits F and G, did you make any other charts with the same Wyatt and Lehr apparatus?

A. Yes; there were a number of charts made at this time.

Mr. Mattingly: Mr. Babcock, will it be understood that the references to the Wyatt and Lehr apparatus which you are making here is the apparatus constructed by Mr. Cornes, and does not necessarily mean the apparatus of the patent? [301]

Mr. Babcock: Well, the witness has testified that it is; but that is correct, that is what I am referring to, the apparatus the witness built.

Mr. Mattingly: That is correct.

Mr. Babcock: Built like the Wyatt and Lehr Figure 2 of the patent.

Q. These graphs, Exhibits F and G, indicate where the fluid level was in that test well?

A. Yes, they do.

Q. In experimenting with this Wyatt and Lehr apparatus did you ever employ different gas pressures in the pressure impulse chamber?

A. Yes, we did.

Q. What difference in result did you get?

A. The results were all very similar, and the differences in intensity of the wave picked up could

(Testimony of Randolph W. Cornes.)

be sufficiently amplified by the amplifier to give a good record in all cases.

Q. I gather that when you used the low pressure in the pressure impulse chamber the echoes were not so strong and required greater amplification by your electric amplifier.

A. That is what I meant, yes.

Q. And when the pressure in the pressure impulse chamber was higher it required less electrical amplification to make a good record?

A. Yes. [302]

Mr. Babcock: I hand the witness a photograph which I will ask the clerk to mark for purposes of identification as Defendant's Exhibit H.

Q. Please state what it is.

A. That is an illustration showing the Wyatt and Lehr apparatus attached to the well in Duncan, on which these tests were made. That is using the Wyatt and Lehr chamber with the hot wire microphone. That is the Wyatt and Lehr apparatus we have talked about. The pressure chamber is above and to the left of the box containing the recording equipment. It is the cylinder with the gauge attached. Immediately to the right of the pressure impulse chamber is the quick-opening valve. On the right-hand side of the casing is, first, attached a butterfly valve, and then beyond that is the hot-wire microphone. The hot-wire microphone was connected through the cable to the recording and amplifying apparatus in the center of the picture.

(Testimony of Randolph W. Cornes.)

Q. Was any filter used in any of these tes with the Wyatt and Lehr apparatus?

A. No filter was used in the Exhibits F and

Q. And the amplifying and recording apparatu is that in the box shown just to the front and the left of the casing of the well?

A. That is right.

Q. I will ask the witness to mark in ink on th photograph Exhibit H the pressure impulse char ber. Mark it "H-1". Mark the [303] quick-ope ing valve "H-2". The casing of the well "H-3 The butterfly valve "H-4". The hot-wire micr phone, or where it is in the pipe "H-5". And th box containing the amplifier and recorder "H-6".

A. I have done so.

Mr. Babcock: I have asked the clerk to mar another photograph for identification as Defen ant's Exhibit I.

Q. I hand this to the witness and ask him state what it is.

A. This is an illustration showing the Wya and Lehr apparatus, using the carbon microphon attached to the well in Duncan.

Q. Is this apparatus the same as that shown Exhibit H, except for the difference in the micr phone?

A. Yes; it is. The carbon microphone is in th pipe fitting just under and slightly to the righ of the hand holding a ruler. It is placed in th same place in the mechanism that the hot-wire m crophone was placed in the apparatus shown

(Testimony of Randolph W. Cornes.)

Exhibit H. The man in the photograph is Dr. Mackeown. The pressure impulse chamber shown in Exhibits H and I is the same piece of apparatus which is here in the court room and which I described to the Court.

Mr. Babcock: Since these tests were made ex parte and at Duncan, Oklahoma, I wish to make this offer on the record: We will repeat the experiments or tests with this apparatus in the presence of counsel or other designated party for the plaintiff, or in the presence of the Court if the Court cares to watch them [304] on some well here in California, at a time that can conveniently be arranged, if the Court or the counsel for plaintiffs so request.

I have one other photograph which I will ask the clerk to mark for identification as Defendant's Exhibit J.

Q. This appears to be a photograph of the defendant's commercial apparatus here in court; is that correct?

A. Yes, it is. This is a photograph of the exact apparatus, the exact piece of apparatus here in court.

Q. Will you please mark on this photograph, Exhibit J, with a pen, the following: Mark the gun with the numeral "J-1". Mark the Y-pipe "J-2". Mark the coupling connecting the gun to the Y-pipe "J-3". Mark the butterfly valve in the upper branch of the Y-pipe "J-4". Just to the

(Testimony of Randolph W. Cornes.)

right of the butterfly valve is another coupling. that the one that contains the hot-wire microphon

A. Yes, it is.

Q. Mark that "J-5". Mark the surge chamb "J-6". The pressure gauge "J-7". And the b containing the amplifier, filter and recorder "J-8

A. I have done so.

Cross Examination

By Mr. Mattingly: Q. Mr. Cornes, I belie you testified you were in charge of Echo-Meter d vision of the Halliburton Oil [305] Well Cementi Company, is that correct?

A. Yes; I am. I am in charge of the maki of fluid level tests with the Echo-Meter apparat used by Halliburton Oil Well Cementing Compan and I am also in charge of the making of pressu determinations and maximum production determin tions of oil wells, using the Echo-Meter apparatu

Q. And you are in charge also of the maki of density determinations with that Echo-Met apparatus, if, as, and when the density determin tions are made with that apparatus?

A. Well, we don't make them.

Q. Does the Halliburton Oil Well Cementi Company make density determinations, using t Echo-Meter apparatus?

A. Not to my knowledge.

Q. Do you know of any instance in which t Echo-Meter apparatus has been used by the Hall burton Oil Well Cementing Company in the ma ing of density determinations?

(Testimony of Randolph W. Cornes.)

A. I don't know of any to my own knowledge that have been made. Some have been pointed out, some were turned over to us that apparently had been made.

Q. What do you mean by "some have been turned over to us"?

A. Well, I have seen several copies of reports which supposedly were made by our men, which were presented by the plaintiffs.

Mr. Babcock: Q. You mean in this lawsuit?

A. Yes, that is right; in this lawsuit. [306]

Mr. Mattingly: How long have you been connected with the Echo-Meter business?

A. I have been with Halliburton since August of 1940.

Q. And did you have any connection with the Echo-Meter business prior to that time?

A. With International Geophysics; yes. I was with them for just over three years prior to that time.

Q. Did you go with the Halliburton Oil Well Cementing Company at the time they purchased the Echo-Meter business from the International Geophysics, Inc.? A. No, I did not.

Q. When did you start work with the International Geophysics, Inc.?

A. Along in November of 1937.

Q. And were you employed by the International Geophysics continuously from that time until the sale of that business to the Halliburton Oil Well Cementing Company? A. Yes.

(Testimony of Randolph W. Cornes.)

Q. While you were employed by the International Geophysics, Inc., was the business of that company known as the Echo-Meter business?

A. A part of the busines of International Geophysics was Echo-Meter business.

Q. And that part of the business which was known as the Echo-Meter business relates to the use of the same apparatus [307] and the practice of the same methods which are now being conducted by the Halliburton Oil Well Cementing Company under the name of Echo-Meter business?

A. The method and apparatus are substantially the same.

Q. I refer you to the enlarged drawing, Exhibit 14 for identification, and ask whether or not that drawing is a correct representation of the casing-head unit which was demonstrated to the Court yesterday in the demonstration made by you?

A. There are slight differenees in construction, but it is substantially the same unit.

Q. And in the demonstration apparatus which you demonstrated yesterday, the gun which you demonstrated is pictured at 10 on this drawing Exhibit 14? A. Yes.

Q. And the part marked 11 on drawing, Exhibit 14, is that part on the demonstration Exhibit? A. Yes; it is.

Q. That is the electrical firing solenoid which is contained in the outer end of the gun mechanism of the demonstration unit here?

A. That is right. That equipment is all one

(Testimony of Randolph W. Cornes.)

diameter, rather than having a change as the drawing shows.

Q. But in so far as the construction and its operation is concerned, the picturization of that in Exhibit 14 is the same as the demonstration exhibit? [308]

A. This valve here is not on the demonstration exhibit.

Mr. Babcock: The witness is pointing to a valve immediately below the numeral 10 on the chart marked Exhibit 14.

A. And the pressure gauge 15 is not mounted on that unit now. Otherwise, I believe it is the same.

Mr. Mattingly: Q. The Y-pipe fitting referred to as 9 is the same as the Y-fitting which you have in the demonstration apparatus here?

A. It has the same function; yes.

Q. And that is merely a piece of pipe with two branches, is that correct?

A. In that unit there, there are several pieces attached to the branch, but that is the purpose of the pipe.

Q. But the Y-fitting itself is merely a piece of pipe with two branches to it? And that is the same as pictured on Exhibit 14 by this Y-pipe fitting 9?

A. Yes.

Q. There is nothing inside of that Y-fitting in the demonstration apparatus, is there? I am referring only to the Y-pipe fitting, not to the parts that are connecting or connected to it.

(Testimony of Randolph W. Cornes.)

A. In that fitting on the floor there are a number of quarter-inch pipes inside of the branch to which the gun is connected, and the other branch to which the microphone is connected, of course, has the butterfly valve. [309]

Q. And the number of quarter-inch pipes which you say are in one branch of that fitting, what is the purpose of that?

A. Those are what are normally called flame arresters. They are to cool gases from the shot and to catch or break up the wadding from the shot. It is just a safety measure. The equipment operates equally well without it.

Q. And the butterfly valve which you referred to that is in the other branch of the Y-pipe fitting on that demonstration model here is pictured on Exhibit 14 as being connected to the Y-pipe fitting 9, instead of being mounted directly in it?

A. Yes; that is right.

Q. As in the demonstration model. But otherwise, the structure and its operation of the Y-fitting are pictured on Exhibit 14, is that correct?

A. Yes.

Q. In Exhibit 14 there is a piece of pipe or a pipe fitting marked 14. Is that piece on the demonstration model here?

A. Yes; it is. Well, it is in a slightly different position. The manner in which the microphone is electrically connected to the unit on the floor is reversed from the way it is in Exhibit 14, merely as a matter of convenience in structure.

(Testimony of Randolph W. Cornes.)

Q. But the general construction and the operation of the microphone 18 and the electrical connection box 16, as pictured on Exhibit 14, are the same as on the demonstration model, is that correct?

[310]

A. Yes.

Q. And the surge chamber 17 which is marked on Exhibit 14 is the same as the surge chamber which you have in the demonstration model?

A. Yes; for the same purpose. It is a different diameter.

Q. And the connection from the bottom of the pipe fitting, of the Y-fitting 9, to the casinghead of the well, as indicated at 7 on Exhibit 14, is the same in its operation as the connection on the demonstration model here between the Y-fitting and the end of the rubber hose used in the demonstration yesterday, is that correct?

A. The size and the manner of connection, of course, differs, but the operation is the same.

Q. In other words, the demonstration model has a fitting which adapts the demonstration model to be connected to the end of a rubber hose; whereas, in Exhibit 14, the fitting which adapts the Y-pipe fitting to be connected to the casing of the well is the same in its structure except for the fact that there are shown valves and curved pipe fittings to make that connection, is that correct?

A. Yes; it is.

Q. And the only purpose of the valves and curved pipe fittings, as shown in Exhibit 14, is to

(Testimony of Randolph W. Cornes.)

make a connection between the Y-pipe fitting and the inside of the casing of the well so [311] that the waves will be able to pass from the Y-fitting down down into the well casing and the echoes will be able to pass back up to the microphone in the casinghead unit? A. That is right.

Q. Does Exhibit 14 represent to you a correct and accurate picture of the defendant's apparatus as it would appear connected to a typical oil well in the field such as you would use in making an actual fluid level test in the field?

A. It is correct as a diagram. It is not an exact illustration, of course, that you would have in a picture. There are slight constructional differences in the shape of the box, etc.

Q. And the oil well representation which is made on Exhibit 14, showing a well bore, a well casing, a string of tubing inside the well casing, the collars or joints in the tubing, the tubing catcher, the sucker rods going down through the tubing, the representation of the pump, is a diagrammatic representation of a real oil well, is that correct?

A. Yes, it is.

Q. Such as that upon which the defendant would and does make fluid level determinations?

A. Yes.

Q. And that representation which is made on Exhibit 14 of the transducer box 21 contains the electrical amplifier and the filter which you testified yesterday was in this box on the floor in the

(Testimony of Randolph W. Cornes.)

court room, connected to the gun and microphone in the [312] demonstration model, is that correct?

A. Yes; it is.

Q. And the recorder box which is indicated at 22 on the Exhibit 14, that is a representation of the recorder which is also contained in the box on the floor of the court room of the demonstration model to which we have just referred, is that correct? A. Yes; it is.

Q. In the demonstration that you made yesterday a record was produced. That record is Exhibit C. Will you look at that record and tell me what are the curves or wiggles in that line immediately to the right of the large wiggle that you have marked "End of hose"?

A. That is a part of the characterstic marking from any reflection. I think you will find that on most records, that you get a kick in one direction representing a reflection, and then there will be a movement back and forth following that.

Q. How did you recognize that mark which you have indicated as "End of hose"? How did you recognize that as the end of the hose?

A. Because it is a steeper mark than those preceding it and is characteristic of that type of reflection.

Q. Can you explain what you mean by "it is characteristic of that type of reflection"? [313]

A. Well, you would get the same or very similar reflection from the fluid level where you were working on a well.

(Testimony of Randolph W. Cornes.)

Q. Then, that mark might mean fluid level, instead of "End of hose", is that right?

A. Well, it would be the same thing. It is just the bottom, as far as you can go.

Q. You also picked out another one of the wiggles in that line and marked that "Coupling echo". Will you tell us how you could identify that little wiggle from the rest of the little wiggles to call it a coupling echo?

A. I identify it by its position and also because it is slightly larger than some of the other movements there which are probably caused by noise, extraneous movements of sounds picked up.

Q. Do I understand you to mean by that that it was half way between the shot—half way between the point you marked "Shot" and the point you marked "End of hose"? A. Yes.

Q. In other words, you knew the coupling was half way along the hose and therefore you could pick out a wiggle about half way between the "Shot" and the "End of hose" marks, and you assumed that that was the coupling, is that right?

A. Yes; that's right.

Q. If you had not known where that coupling was with reference to the hose, do you think you would have been able to pick out one of the wiggles and definitely know it was a coupling?

A. I think I would. [314]

Q. Wouldn't the wiggle that you have marked "End of hose (2)" also look like the echo or a

(Testimony of Randolph W. Cornes.)

record that you got from the coupling or that you have identified as the coupling echo?

A. It looks similar, but it is in the wrong position.

Q. You mean it is in the wrong position along the tape? A. Yes.

Q. To be the coupling echo. So that in picking the "Coupling echo" and the "End of hose" and "End of hose (2)" you selected those particular points merely by their position along the record strip, is that right? A. Yes, it is.

Q. These other wiggles which the court asked you about yesterday, lying between the mark "End of hose" and the mark "End of hose (2)", they also look like coupling echoes, don't they?

A. They are somewhat similar.

Q. If you had not seen this piece of hose and you had not conducted the experiment, but you had been merely given this chart, would you have said that those extra wiggles were probably coupling echoes? A. No; I wouldn't.

Q. However, they do look the same as the other echoes that you picked out up here and marked "coupling echoes", don't they?

A. Yes; they look similar. [315]

Q. So unless you knew in advance what the length of that hose was and where the coupling was located along the hose, you would not have been able to pick out one of those little wiggles and say "That is the coupling echo", would you?

A. I wouldn't say definitely—if I hadn't known the length of the hose, I wouldn't definitely know

(Testimony of Randolph W. Cornes.)

that this first echo mark marked "Coupling echo" was a coupling echo; but from the characteristic of the "End of hose" section, I think I would not have placed any emphasis at all on these following, because the amplitude of those was too small, and knowing how the equipment operates and being familiar with the interpretation of records, you would naturally not place any emphasis on those, you would not necessarily need to know all about the hose to throw those out.

Q. If there had been a hole in the hose somewhere along its length would that hole have registered an echo on the record strip?

A. If it had been of sufficient size.

Q. And would the record of that be any different from the record of the coupling?

A. It would probably look the same. I have never tried that but I would say that it would be similar.

Q. Can you tell us whether or not in the Echo-Meter apparatus the defendant uses the records which you get back from a well show obstructions extending into the well and they also [316] show records of enlargements which may be in the well, do they not?

A. Yes; they show reflection from either type of change in the diameter.

Q. Do those records of those two different things show up in the Echo-Meter records differently, or do they look alike?

(Testimony of Randolph W. Cornes.)

A. Reflections of the same amplitude would look about the same.

Mr. Babcock: Q. Are you familiar enough with the plaintiffs' apparatus, the Depthograph, to know whether that would be true with their apparatus?

A. I believe on their apparatus a reflection from an enlargement would represent a movement in the opposite direction.

Q. In other words, with their apparatus a reflection from a hole in the pipe would show up differently from a reflection from the collar?

A. Yes; it would.

Q. And how about as to the Echo-Meter?

A. They would show up the same with the Echo-Meter?

Mr. Mattingly: Q. If this record chart had been shown to you and you had not been told anything about the conditions under which that chart was made, what would you have interpreted that chart to represent? Will you tell us that?

A. Well, it would look similar to a record made in a shallow well. [317]

Q. And the wiggles along the line there might represent coupling collar echoes—would you have understood them?

A. They could, but very seldom in a shallow well do you get particularly good reflections; that is, when you get too shallow they are difficult to pick out.

(Testimony of Randolph W. Cornes.)

Q. Yesterday you testified about some tests that were made at a Union Oil Company well at Dominguez and you produced some record strips that were made at the time that demonstration tests were conducted. Do you know how deep that well was?

A. You mean total depth of the well?

Q. Yes. A. No; I do not.

Q. Do you know what size the tubing was in the well?

A. No; not exactly. Either two or two and one-half. I don't recall. I don't remember whether I asked or not.

Q. Do you remember what the size of the casing was in that well?

A. I think it was approximately 6 or 7 inches, but I didn't pay any particular attention.

Q. That well was static, was it not, at the time these tests were made? A. Yes; it was.

Q. And by that do we both mean the same thing, that the pump was not running at the time the tests were being made? [318]

A. The pump was not running and the casing was closed in and supposedly the tubing was also closed. By "closed in" I mean shut off.

Q. The valve was closed on the well we had the demonstration test on, was that right?

A. Yes.

Q. And the tubing might also have had a valve in it, but that was closed, too, was that right?

A. I didn't check it, but it should have been closed.

(Testimony of Randolph W. Cornes.)

Q. Do you recall what the pressure was in the casinghead of the well at the time the demonstration test was made? A. Approximately 90 pounds.

Q. I refer you to Exhibit D. These record strips shown on Exhibit D are copies of the actual records which were made by the Echo-Meter apparatus at that well during that demonstration test, is that right? A. Yes, it is.

Q. The record strip No. 1 on Exhibit D shows a lot of wiggles along the line. What is each one of these wiggles?

A. Each of the wiggles between the "Shot" point and the "Fluid reflection" represents coupling collars, each of the larger wiggles, tubing collar reflections.

Q. And is the same thing true on the record strip 2? A. Yes, it is. [319]

Q. The first ten wiggles on record strip 1 and the first ten wiggles on record strip 2 represent echoes from exactly the same collars, is that correct?

A. Yes, sir. The same ten collars that are disposed immediately below the upper end of the well. The record strip 1 was made with the Echo-Meter apparatus with the filter out of the circuit. And the record strip 2 was made by the Echo-Meter apparatus with the filter in the circuit and set correctly for the frequency of the collar echoes in that particular well.

Q. And the collar echoes which appear on record strip 2 are not represented as strongly as those on record strip 1, are they? A. No; they are not.

(Testimony of Randolph W. Cornes.)

Q. Then the tuning of the recorder there did not have much effect on bringing out or amplifying those tubing collar echoes, did it? A. No.

Mr. Babcock: Q. Was the amplifier set the same in charts 1 and 2?

A. Approximately the same. I don't remember exactly what the settings were. There might have been some difference there.

Mr. Mattingly: Q. So far as you know, the amplifier was set the same in both cases?

A. No; I wouldn't say so. I would say it was almost the [320] same. There might have been considerable difference in amplification between the two.

Q. In other words, the strip 1 might have been made with the amplifier set at one value and strip 2 with the amplifier set at a different value?

A. The value was probably changed throughout each of those records as they were being made. In other words, starting at a low value and increasing it.

Q. But that did not have anything to do with the frequency setting?

A. No. After the shot was fired during the time that the apparatus was running and in between the firing of the shot and the echo from the fluid reflection I may have changed the amount of amplification on each of these charts 1 and 2.

Q. But as far as you know, the starting value of the amplification and the end value of the amplification in both strips was the same, was it not?

(Testimony of Randolph W. Cornes.)

A. No. We made no record of either the starting or the end values, and I don't remember. They probably were not the same at the end, even though they might have been the same at the start.

Mr. Babcock: I would like to put this on the record: Counsel, I take it, is referring on all these charts to the "kicks", let us call them, between the shot and the first fluid level [321] reflection in referring to these tubing collar echoes, are you not?

Mr. Mattingly: That is right. And I think, for the convenience of the Court in determining just what reflections we are referring to, I would like to have the witness mark Exhibit D to indicate the beginning of the recording of the echoes.

A. I have marked the "Shot point" on each of these six records, marked it "Shot".

Q. I believe you testified that in the practice of the defendant in finding fluid reflections with the Echo-Meter apparatus, they did not always use a filter in the circuit, is that right? A. Yes.

Q. How do you determine whether you are going to use the filter in the circuit or not?

A. From the appearance of the first record which is made without the filter. The first record (Chart 1 of Exhibit D) here shows uniform and distinct collar reflections. These are sufficiently distinct so that there would be no particular need of using the filter. However, in some cases the collars may not be distinct, there may be other reflections, minor reflections or noises in the well, minor reflections from dirt or casing collars or something else in the

(Testimony of Randolph W. Cornes.)

well, and which would cause the record to be indistinct and hard to read. In that case it would [322] probably be advisable and help to use the filter in the well.

Q. That would be if you would fire a first shot into the well, make a record, take a look at that record, and if the collar echoes were distinct, then you would not use the filter, is that right?

A. Yes, there would be no need to. Some operators have a habit of using it, and others don't like it at all. But if they were distinct there was no reason to use it.

Q. And then if you fired your shot and the collar echoes, that is, your wiggles in the line, were so you couldn't tell whether they were collar echoes or not, then you would fire another shot and use your filter in the circuit, is that correct?

A. Yes. You would figure out your filter setting from the first record and use it in the second one to see whether there was any improvement.

Q. So when you say you don't always use it, you mean that there are some conditions in oil wells under which you will make a record that you do not necessarily require the filter, is that right?

A. Yes.

Q. But in most of the wells that your company measures with the Echo-Meter apparatus you do use the filter in the circuit?

A. No. I would not say in the most, probably less than half. I never counted the records and don't know exactly, but I know in Kansas, where

(Testimony of Randolph W. Cornes.)

the large percentage of our work is done, [323] the operators there do not use the filter at all. Some of them have even taken it out of their instruments. In some areas it is used more than others. It somewhat depends upon the preference of the operator as to whether he wants to try it or not.

Q. Does the filter which is used by the defendant filter and amplify frequency which is produced by reflections from the tubing collars?

A. The filter does not do any amplifying. The amplifier does all the amplifying, and the filter or feed back circuit, which accomplishes what we call the filtering, merely reduces the intensity of echoes arriving at some other frequency than the tubing collar echoes.

Q. But the filter does not amplify or cause the tubing collar echoes to be amplified more than they would be if the filter was not used, is that right?

A. Generally, the intensity is even reduced over what it would be without the filter, with the same amplifier setting.

Q. I believe you described yesterday a control knob or handle on the instrument which was demonstrated in the court room here that was used to adjust the filter, is that correct?

A. That is used in that instrument on the floor. It is used to turn the filter on and adjust the setting.

Q. And does that knob adjust the frequency to which the filter will respond?

A. Yes; it does. [324]

(Testimony of Randolph W. Cornes.)

Mr. Babcock: Q. Let me ask what determines the frequency of these echoes.

A. The frequency of the echoes is determined by the spacing of the collar on the pipe and by the velocity of sound in the pipe. The filter setting, the actual calibration is calibrated in millimeter spacing between reflections. No reference is made on the instrument to frequency. The original calibration is—well, it is not even then made in terms of frequency exactly. If you are putting in an oscillator a certain wave, you could set that for a certain frequency, but in the field no reference is made to the frequency; it is made to collar spacing. The calibration of that instrument makes no reference to frequency.

Mr. Mattingly: I didn't ask about the calibration on the instrument. I merely asked: Does the control knob of this filter adjust the frequency to which that filter will respond? A. It does, yes.

Q. That is the nature of the construction of the filter, isn't it?

A. That is right. All filters are concerned with frequencies.

Q. Does this filter act with the amplifier to cause the amplifier to have a tendency to oscillate at the frequency for which the knob is set?

Mr. Babcock: I believe I will object to that question, [325] unless you ask him first if an amplifier oscillates.

A. An amplifier will pass the frequency for

(Testimony of Randolph W. Cornes.)

which the knob is set; so far as oscillating by itself, it shouldn't do that.

Q. But the amplifier has a natural tendency to oscillate at the frequency of these tubing collar echoes which come back from the well and for which frequency of tubing collar echoes your filter collar has been set; is that correct?

A. No amplifier should oscillate. I don't think that one has a tendency—could be said to have a tendency to oscillate, that is, it won't oscillate of its own accord.

Q. But it will oscillate to frequencies for which the filter has been set, will it not?

A. No; I don't think it would. To oscillate it would have to keep going by itself, and it won't do that.

Q. Doesn't the filter that is used by the defendant select out a certain limited narrow band of frequencies from all of the frequencies that are put into the amplifier, and then feed back into the amplifier those frequencies within that limited band?

A. Well, we are going into the electrical characteristics of the operation of the amplifier there. If you want a complete description, your description is not accurate there. The reverse actually happens. That is, approximately the reverse of what you stated.

Q. Will you state what does happen?

A. The filter is so constructed that the amplifier takes [326] what is picked up from the well and amplifies it through the three stages of the amplifier,

(Testimony of Randolph W. Cornes.)

and then those frequencies of signals to which the filter is not set to respond are fed back from the output of the amplifier to the second stage, I believe it is, of the amplifier, where they tend to cancel out those extraneous signals, and the signals for which the filter is set, the tubing collar, uniformly recurring tubing collar reflections are allowed to pass through the amplifier, but the intensity, though, is not increased by the filter. The amplifier does all the amplifying and the filter merely cancels out other signals.

Q. Did you have anything to do with the preparation of the construction book, Plaintiffs' Exhibit 11-C?

A. No; I did not. That is the field manual it is called.

Q. Do you know whether or not that book correctly describes the defendant's apparatus and the way it operates?

A. There are minor technical errors in there which an electrical engineer probably would not have put in; but so far as the field operation, the actual technique of taking fluid levels is concerned, I think the manual is substantially correct.

Q. Does the pressure of the gas in the casing-head of the well have any effect upon the clarity of the registration of tubing collar echoes?

A. I would make a general statement that it does. An increase in pressure generally reduces the amplification necessary to get [327] a record, but at

(Testimony of Randolph W. Cornes.)

times an increase in pressure may have a detrimental effect rather than it being advantageous.

Q. Does the length of the annular space in the well between the casinghead and the fluid surface affect the clarity with which your tubing collar echoes will register?

A. As the well gets deeper more amplification is necessary, and it is occasionally impossible to get tubing collar echoes to the bottom.

Q. And in the case of one of those deep wells like that, would that be one of the occasions when you would have to use your filter in order to bring out those tubing collar echoes?

A. It might make them more distinct and it might not. Generally, I think it would aid in counting, at least, those lower reflections.

Q. Were you present at Duncan at the time this instruction book 11-C was being written and compiled?

A. No; I was not employed by Halliburton at that time, that is; that is dated July, 1940, is that right?

Q. That is correct.

A. I started work for Halliburton on August 2, 1940.

Q. And that was after the book was completed?

A. That is right.

Q. Well, would you say that the description on page 13 of this book of the operation of the filter of the defendant is a correct statement? [328]

(Testimony of Randolph W. Cornes.)

A. So far as the electrical operation of the filter goes the statement is not correct.

Q. Do you know whether or not that was a correct statement of the operation of the apparatus which was used by the defendant at the time the book was written? A. It is not correct.

Q. Is it a correct statement of the apparatus and its operation as used by the defendant now?

A. No.

Mr. Babcock: Q. In your previous testimony you have given the correct operation of the filter, haven't you?

A. I think I have pointed out most of the points regarding the filter.

Mr. Mattingly: Q. Will you tell us how you know that that did not correctly describe the filter which was used by the defendant at the time the book was written, if you were not employed by the Halliburton Oil Well Cementing Company at that time?

A. The Halliburton Oil Well Cementing Company purchased all the instruments which they used up to that time from the International Geophysics, and I was employed by International Geophysics and constructed a large percentage of the instruments which Halliburton was using, and designed and introduced the filter into the instruments myself.

Q. So, you were the one who designed the filter in this apparatus? [329]

A. Yes; I designed or adapted it, that is, I adapted the circuit to the apparatus.

(Testimony of Randolph W. Cornes.)

Q. Do you know when that was first used?

A. Your question refers to when this type of filter circuit was first used in Echo-Meter equipment, do I understand?

Q. That is right.

A. About February, 1940. I don't remember the exact date. But we were experimenting with this equipment about that time.

Q. And has there been any radical change in the filter which was used in the Echo-Meter apparatus since that time?

A. The filter equipment used in all of the instruments in the field at that time was substantially the same. In this smaller instrument on the floor one of the controls was left off. Just a fixed setting was used on what is called the Decrement control in the manual, and the on and off switch was combined with the other control. But the circuit and operation is substantially the same and has been since it was first produced.

Q. You were with the International Geophysics in February, 1940?

A. Yes. I left them toward the end of July in 1940 and went with the Halliburton Oil Well Cementing Company within a week or ten days, so that throughout this entire period of time I was thoroughly familiar with the Echo-Meter apparatus and the filter. I was employed by the International Geophysics company during the late summer and fall of 1939. [330]

(Testimony of Randolph W. Cornes.)

Q. Do you know whether or not during that time this Echo-Meter equipment was being used to test or find fluid levels in wells at Huntington Beach for the Standard Oil Company?

Mr. Babcock: This matter was not touched on in direct examination.

Mr. Mattingly: Well, that is true. Then, if you want to put in an objection based upon that you may do so.

Mr. Babcock: Well, go ahead; he is your witness.

A. We did several days', or maybe weeks', work down there at Huntington Beach for the Standard. A charge was not made for part, and perhaps for any of that. I don't know.

Mr. Mattingly: Q. Do you know why there was no charge made for that?

A. The type of well they had there was quite different to work on, and we were not satisfied, and neither were they, with the operation at that time, that is, the results that we and they were getting.

Q. Do you know why those results were not satisfactory?

A. It was a combination of factors. I think they gave us insufficient well data to work with, and we were not absolutely satisfied with the fluid reflections which we were getting. In other words, we did not have sufficient confidence in our data to want to turn it over to them as commercial operations.

Q. Do you know whether or not the records that you obtained in those wells distinguished tubing

(Testimony of Randolph W. Cornes.)

collar echoes from fluid level [331] echoes and other noise echoes?

A. You want to know if the fluid level reflections were distinguished from tubing collar reflections?

Q. And other noises in the well.

A. As I remember it, in general we got very good tubing collar reflections. The principal trouble on those wells was that they had a catcher and liner set in practically all of them and we had some difficulty in distinguishing fluid level from the liner, and since they are both the same type of reflection and they in some instances did not give us correct data on the depth of the liner—I don't remember the number of the well, but on several wells the liners were set when the wells were first drilled and their records seemed to be in error. But so far as getting tubing collars and knowing they were tubing collars, I think the results were quite satisfactory.

Q. I refer you to Exhibit 11-C, the sheet of drawings which appears immediately in front of page 14 of that exhibit, and ask whether or not the wiring diagram which is shown on that drawing is a correct representation of the wiring employed by the defendant in its filter on its Echo-Meter apparatus? In other words, is that drawing right?

A. That drawing is right for the instruments in which it was used, which includes all the instruments up until this smaller instrument here in court was constructed. The circuit of that is the same as this, except for differences of the values. [332] That was constructed some time during the spring of 1942.

(Testimony of Randolph W. Cornes.)

Q. And the defendant is still using in the field instruments which include a filter corresponding to the diagram which appears before page 14 of this book, Exhibit 11-C? A. That is right.

Q. And will you also look at the two diagrams which appear immediately following page 11, the first two sheets immediately following page 11 of Exhibit 11-C, and state whether or not those diagrams are a correct representation of the circuits employed by the defendant in its Echo-Meter apparatus? A. Yes; they are.

Q. And those diagrams are correct for the amplifier apparatus shown now in the new instrument which you have just pointed out?

A. No. They are correct for the older instruments. There are some changes in the new instrument which is now on the floor.

Mr. Mattingly: That is all.

Redirect Examination

Mr. Babcock: Q. You have just referred to these diagrams here on the amplifier following page 11. Is there anything essentially different in those diagrams and the actual apparatus here in the courtroom as to the amplifier?

A. So far as the performance of the amplifier goes the two are essentially the same. There is differences in values and difference in the coupling between some of the amplifier stages. [333]

Mr. Graham: I offer in evidence Exhibits H and I, which are photographs showing Wyatt and Lehr apparatus, attached to the well in Duncan.

(Testimony of Randolph W. Cornes.)

I offer as Exhibit J, a photograph of defendant's commercial apparatus, that we had here in the court room.

The apparatus of Exhibits H and I were built by the witness Cornes or under his direction, for these experiments that were made at Duncan, Oklahoma.

The Court: From the specifications set forth in the Wyatt and Lehr patent?

Mr. Graham: According to that, your Honor.

The Court: They are in evidence as defendant's exhibits, and so received.

Mr. Mattingly: At this time, I would like to offer the enlarged drawing, Exhibit 14, which is on the easel, as Plaintiffs' Exhibit 14, and Exhibit 15, the record strip which the witness testified was made on the apparatus in accordance with the photograph Exhibit H. Then as Plaintiffs' Exhibit 16, a group of other record strips which were made with the apparatus, as shown in Exhibits H and I.

[Printer's Note: Defendant's Exhibits H, I, J, are set out in full in the Book of Exhibits.]

[Printer's Note: Plaintiffs' Exhibit No. 14 is set out in full in the Book of Exhibits.] [334]

SAMUEL S. MACKEOWN

a witness on behalf of the defendant, testified as follows:

My address is 124 Arden Road, Pasadena. I graduated from Cornell University in 1917, major-

(Testimony of Samuel S. MacKeown.)

ing in science, and was admitted to the graduat school in the last part of that year, but in June o 1917 I accepted a position with the Bureau o Standards, in Washington, D. C. as laborator assistant. Some of my first work there was on sound ranging device for locating gun fire, whic shortly went overseas. Then I was transferred t work for the Signal Corps, and in March, 1918, was granted a commission as a second lieutenant i the Signal Corps, and assigned to duty at the devel opment laboratory at Camp Vail, New Jersey; tha is now Fort Mammoth; and had charge of experi mental work on the development of airplane radi receivers and transmitters.

In September of 1918 I was transferred to th office of the chief signal officer in Washington, D. C. in charge of development of new types of radi tubes for the Signal Corps. In February of 1919 I was discharged from the Army and returned tem porarily to the Bureau of Standards, in their radi division, as assistant physicist. In July of that year I accepted a position as a research engineer in the engineering department of the Western Electric Company. That is now the Bell Telephone Laboratories, Inc. In September, 1920, I returned to Cornell University as an instructor in physics, and was an instructor [335] in physics and a graduate student there until June, 1923, when I was granted the degree of Doctor of Philosophy, majoring in physics.

In September of 1923, I came to the California Institute of Technology as a national research fel-

(Testimony of Samuel S. MacKeown.)

low of the Rockefeller Foundation, which position I held until 1926. In the summer of 1926 I took a temporary position with the research staff of the Westinghouse Lamp Works at Bloomfield, New Jersey, and in the fall of 1926 I returned to the California Institute on the staff both in the physics department and electrical engineering. Since 1926 I have been at the California Institute of Technology, and have had charge of the work in radio, communications, sound recording, electronics and such fields.

My courses consist of courses in communications and certain filters, resonance circuits, and methods of recording sound, reproducing sounds, microphones, and so forth, and I am professor of electrical engineering in the California Institute of Technology.

I have been called during the past ten or twelve years by different companies to act as an expert and testify in a number of patent cases. Some of those have been the General Electric Company on Tungsten Filament. That was a case heard in this district, where testimony was taken before Mr. Head as Master for Judge McCormick, I believe; on the Neon Light patents [336] before Judge Cosgrove; before the late Judge James in the Technicolor case, and before Judge Yankwich in the Hookless Fastener case, that is the zipper; and several cases for the Western Electric Company, and the American Telephone and Telegraph Company, on sound recording, and by the Radio Corporation of America

(Testimony of Samuel S. MacKeown.)

on both sound recording and radio cases; and by the Halliburton Oil Well Cementing Company in a case before Judge Kennerly in Houston, on electrical logging of oil wells, that was the Schlumberger case. And this summer in a case by the Standard Oil Company on refining of gasoline and special means of controlling temperature.

Mr. Graham: Q. Doctor, at the present time are you connected with any of the technical departments of the armed forces?

A. Yes; I hold, and have held for the past six years a commission as lieutenant commander in the United States Naval Reserves.

I will discuss the patents in suit, particularly the technical points which may cause difficulty to one not familiar with sound and its properties.

In referring to Plaintiffs' Exhibit 1, which is patent 2,156,519, the first two paragraphs, I think need no explanation. There is nothing there that I think is of a technical nature that needs any explanation. I think it is plain to anybody. The paragraph starting on line 16 explains prior methods of determining [337] fluid levels, and divides those into two types. One type is with a line or pressure recorder, or a bailer is lowered into the well and the surface level is determined by the amount of line which has to be let out until the line makes contact with the fluid. It speaks about a pressure recorder, how this pressure recorder can be operated by a clock so that it can make a recrod of the pressure over a considerable period. Then

(Testimony of Samuel S. MacKeown.)

starting at line 37 it refers to the other old method, and I will read that sentence, the last of that paragraph:

"The other method is that of producing sound waves in the well and noting the elapsed time between the introduction of the sound and its return as an echo from the surface of the fluid or other obstruction encountered."

I would like to read the next paragraph before speaking about the sound method, and the differences between the sound wave and the pressure impulse, or possibly you might state it as sound inpulse. Referring to the old methods, the patent continues, on line 42:

"Neither of these methods is satisfactory, the first having the disadvantage of requiring the removal of oil flow tubing, sucker rods and other apparatus normally disposed in the well prior to the time the instrument is inserted in and lowered into the well, requiring a considerable length of time both for the removal of such apparatus, the reinsertion of the apparatus, and the making of the actual measurement." [338]

That is, if you are lowering a large bailer or large pressure recorder, it is necessary to remove the tubing. Then it continues:

"The other method is unsatisfactory primarily because of the relatively low intensity or energy which can be employed in the sound wave so that the echo received back is of such low energy as

(Testimony of Samuel S. MacKeown.)

to prevent its accurate detection and, further, little or no distinction is made by reason of such low energy between various types of obstructions encountered by sound waves."

The two objections are, first, that the energy in a sound wave, this patent states, is low, and second, that there is no characteristic variation or type of response which is characteristic of obstructions encountered by the sound wave. Then the next paragraph:

"A third method, namely, that of producing a shock of relatively high intensity in the well, creating thereby a pressure wave which travels through the well, and measuring the elapsed time between the introduction thereof and the echo thereof, to give an indication of the depth of the fluid level and other obstructions, has been introduced, one form being that of creating an explosion in the well, another form being illustrated and described in United States Letters Patent No. 2,047,974, issued to Harold J. Wyatt and Paul E. Lehr on July 21, 1936. This latter method has the desirable characteristic of permitting the [339] employment of relatively high intensity in the wave or impulse produced in the well and it is an object of my invention to improve upon the method disclosed in that patent and to eliminate or materially reduce factors of error encountered in the employment of that method."

There is seemingly, then, a distinction between sound methods and pressure impulse methods, and

(Testimony of Samuel S. MacKeown.)

I think it would be well to explain what a pressure impulse is and what a sound wave it, so that we can understand the distinction between these two methods.

A pressure impulse is a blast of air in one direction. You blow out through your lips, like that; you get a pressure impulse. A pressure impulse is generally a pressure only in one way. If I can step down to the board I think I can show the difference between these impulses better.

I will plot on the abscissa time. The time will be increased to the right and ordinate, pressure. This line through here will be the constant atmospheric pressure, or the pressure which might exist. I will mark that line A. Zero on this is a vacuum. A can also be referred to, as pressure in the casing before any disturbance is put in.

The Court: It is atmospheric pressure.

A. That casing might be higher than atmospheric pressure. It is whatever pressure is present in the chamber. The pressure impulse would be the pressure wave which might have a form like [340] this, which would always increase the pressure, and not cross its axis; in general, which may be an impulse, a unidirectional pressure. That pressure impulse can have a certain wave shape—I will draw another pressure impulse down here, which would be different. It might look like this, which would be obtained by, say, leaving a valve open for a greater length of time. The first impulse, we will mark it 1, would be the kind of impulse

(Testimony of Samuel S. MacKeown.)

you would get if you open a valve; there is a rather high pressure in that chamber; you close it quickly; then the pressure dies down, by closing the valve. The kind of impulse you can get with the pressure impulse shown on this would be where the magnitude of the actual pressure would be lower; maybe you did not open the valve as high, or maybe the chamber did not have as high a pressure in it, and you kept your valve open for a greater length of time. You can have a negative pressure, or rarefaction. The patent speaks of negative pressure waves, and Mr. Walker spoke about rarefaction, which can be obtained by reducing the pressure. We might have a casing of high atmospheric pressure, and reducing that pressure——

Mr. Graham: Q. May I ask you right there, Doctor, for instance, to illustrate that, if you have a casing pressure of 100 pounds, you open the valve quickly, and let some of that pressure out, that would be negative?

A. That would be negative pressure. [341]

The Court: With positive pressure you blow; with the other you suck?

A. That is right. That would be rarefaction or negative pressure. That would be just the converse of this; and we could have a pressure impulse existing, like No. 3, which would be a negative pressure impulse, or a rarefaction.

Plotting exactly the same thing down here, and marking this A again, for atmospheric pressure, a sound wave, without a pressure impulse, such as

(Testimony of Samuel S. MacKeown.)

would be produced by a stringed instrument, a violin, for instance, would be a wave which would have both a positive and a negative pressure, or a pressure and rarefaction wave crossing the normal or average pressure line, and the frequency of this wave, which is measured between the upper peaks would, of course, determine the pitch of the sound. Middle C, for instance, has a frequency of 256 variations per second, so there would be 256 complete waves or peaks above the line every second when middle C is sounded.

The Court: Above the line?

A. Above the line, not counting the peak below, and the frequency is from these two points from which I have drawn a line.

The Court: From peak to peak?

A. From peak to peak, or from crest to crest, and the distance there is spoken of as the wave length, and the number of those that occur per second is spoken of as frequency. This would be a pure sound wave, as I say, produced by a stringed [342] instrument such as a violin string, where it is excited by bowing. A great many of our instruments actually produce sound by pressure impulse, such as the trumpet, the clarinet, or any of those instruments, which do produce sound, a musical impulse, by an actual pressure impulse, a blast of air. In that case you would have a combination of a pressure impulse and a sound, so that when the sound began you would have this pressure impulse with the sound wave superimposed upon it.

(Testimony of Samuel S. MacKeown.)

The Court: Would that ever come down again, the pressure impulse?

A. This pressure impulse would not come down until the wave dies out. If the wave is excited by a pressure impulse, for instance, if you are blowing a trumpet or a whistle, the whistle is produced by the pressure impulse; the sound through your lips is superimposed on that. You do not realize it, but that is the pressure wave going out followed by a rarefaction wave. As long as that whistle goes you have to excite it by this pressure impulse.

I will mark this a positive pressure impulse. This would be a negative pressure impulse. This would be a sound wave. The lower one would be the sound wave, but you can distinguish between this one and the lower one by calling this a sound impulse. You will find that this is talked of in some cases as a sound impulse. [343]

The Court: What is a violin wave? That is the sound wave with a sine wave superimposed on it?

A. The wave for a violin wouldn't be any simple wave like this, but would have many irregularities superimposed on it.

Q. Following the other wave?

A. I will draw the last portion showing that. That might be a lot of variation superimposed on that.

Q. It would be superimposed on the regular other sound wave? A. Yes.

Q. So you will have two waves?

A. You will have a large number. You will

(Testimony of Samuel S. MacKeown.)

have actually as many as the eleventh harmonic. That is why, if you have the note C struck on the piano, and the note C played by a violin, of equal loudness, you still distinguish the two because of the presence of these harmonics or irregularities which give it the quality of sound which is distinctive, and gives the difference between a violin and a saxophone, and so forth, playing with the same loudness, in the presence of those harmonics.

Q. You call those sine waves?

A. Those are sine waves, but sine waves of a high frequency of harmonics. If this sine wave represents middle C the time between the peaks of this would correspond to 1/256 of a second. And in harmonics we would have also present a frequency of 512, which is the second harmonic. The harmonics are present in nearly [344] all musical instruments. If you don't have harmonics, it is rather a flat note, and they depend on the shape of your sound box and the construction of it, and the quality, the presence of those harmonics, in a manner that an artist thinks is proper. That is what distinguishes an expensive violin from a cheaper one, and gives the tonal qualities desired in an expensive violin.

I might point out that a sound wave, or sound —that the ear is able to hear from a frequency of approximately 16 per second up to, well, we might say 16,000. 16,000 is rather high. I can't hear much above 8,000 cycles. Some people hear up to 20,000,

(Testimony of Samuel S. MacKeown.)

but the average ear would be something like 16 up to 16,000.

The Court: That is the human ear?

A. That is the human ear. A dog will have a higher frequency than a cat. The ear has a terrific range; a range of about 1,000 octaves actually.

This patent then, this apparatus in this patent, as I understand it, is going to use a pressure impulse, shown on the top of the blackboard, rather than a sound wave, or sound impulse. Because in column 1 it speaks of the other method of producing sound waves. Most sound waves are produced by pressure impulse. All of your wind instruments are produced by pressure impulse—all of your wind instruments produce sound by pressure impulse. A gun also produces a pressure impulse.

[345]

A gun would produce a pressure impulse, and superimposed on that would be the sound waves, as shown in the bottom, and that would be followed by a rarefaction wave, after the first pressure wave. The gun is confined, and the wad and bullet move out, and that leaves rarefaction behind, and suction, and it is only the production of that suction that gives you the sound of the gun. The first blast moves out, and produces a vacuum; air rushes in; too much rushes in, and that produces a clap. That goes back and forth. That is the thing that gives the sound of a gun.

The Court: What about echoes?

(Testimony of Samuel S. MacKeown.)

A. Echoes are simply a reflection of sound waves or pressure impulses from any discontinuity. By that I mean, by any wall, or if they are in a tube, by any change in the diameter of the tube or by change in the material in the tube itself. But suppose we talk about these echoes—I will turn this board around—we were interested in sound in a tube, so let's think of that. Suppose we have a tube here, and if I do anything to change that tube, if I bent it around a corner I will get a reflection, or if I put a restriction in here and make this tube narrower, then if I have a pressure wave traveling to the right, when it reaches here there will be reflected back a pressure wave at this point. That would be an echo coming from this tube because of it constriction. [346]

The Court: Would the same thing come back from sound?

A. Sound would be reflected back. The amount, the per cent of the energy that is reflected back will depend on how big this restriction is, and the strength of the echo will be approximately equal to the per cent of the area that is cut off. That is, if I have a restriction here that decreases my area one-half, approximately one-half of the energy will be reflected back at that point.

The Court: Does that same rule apply to pressure impulses and sound impulses?

A. Yes, that same rule would apply to both of them. You would get the same effect. I might say particularly of sound traveling in a tube, we know

(Testimony of Samuel S. MacKeown.)

all about it, it having been worked out by Lord Rayleigh in 1870 or thereabouts. And we know the theory. We can tell you everything, practically, that happens in a theoretical case where we have a uniform tube.

The Court: When sound is introduced into a tube, isn't it the tendency to scramble it due to the echoes from the sides running into one another?

A. There will be that scrambling at the entrance end after the sound is in the tube. After the sound is in the tube it will travel through here and with a loss decreasing in magnitude due to energy losses through the tube. But if the tube remains the same; that is, not a change in diameter or material in it, then this will continue down there, gradually decreasing [347] in size with no scrambling.

The Court: Do these pressure impulses travel at the same rate of speed as sound impulses?

A. They do, yes. The speed is determined entirely by the properties of the gas. They are both what we speak of as pressure impulses or waves.

The Court: What is the difference?

A. The difference is that a pressure impulse is something which we always think of as a pressure increase and never a rarefaction wave. A sound wave is a succession of pressure increases and decreases or waves followed by rarefaction waves, and so forth. They follow very rapidly. I mean, sound waves we speak of in the audible range. The

(Testimony of Samuel S. MacKeown.)

average frequency would be something around 1000 or 2000 cycles.

The Court: If a pressure impuse is introduced into a hollow metal tube, doesn't that create sound, however insignificant? It may not be audible to me, but doesn't it create sound?

A. If you had a pure pressure impulse introduced into a tube, I would say there would be no sound there. It may be difficult, experimentally, to get no sound. It might be a small hiss, but I would say, if it was a pure pressure impulse that there would be no sound. If I blow through my lips you will hear very little sound, but I put my lips close together and I can whistle. Then I have a sound. But if you say, a pure pressure impulse, I would say there was no sound. And if you [348] say a pressure impulse, I would say that that was something in which the sound was very small. It might be a sound from gas escaping through the valve. The impulse would be very large compared to that.

The Court: If the pressure impulse were relleased into the open air there would be less sound than if it were introduced into a hollow metal tube, wouldn't there?

A. No, there would not. It would be only a vibration of the air in the valve. That would be a function, entirely of the opening, the amount of sound wave introduced. It would not make any difference at what rate it was introduced.

The Court: All right.

(Testimony of Samuel S. MacKeown.)

Mr. Graham: Q. On that question: the sound waves are in the audible range, and pressure waves are not?

A. Pressure waves—I don't think we ought to say pressure wave. We ought to say pressure waves coming in one direction. Because a sound wave is a pressure wave in rapid succession. But a pressure impulse, I think, is not a wave. It is all in one direction.

The Court: I would like to hear a pressure impulse introduced into a chamber.

The Witness: We have the apparatus here. We can do that. I don't know what we can introduce it into. We haven't a casing here to introduce it into. We have a hose. [349]

The Court: I am thinking of tuning in a different sense than you people are, apparently. I understood Dr. Mackeown to say there wasn't any sound. I have always had an idea that there was. Maybe I have been hearing things.

The Witness: Your Honor, I said a pressure impulse is something where the sound would be small compared to the pressure impulse. As I said, if you had a pure pressure impulse I would say you had no sound. But practically you will have from that big pressure impulse, some small amount of sound, such as the hiss due to the opening of the valve which, however, is incidental. If you blow through your lips that is a good illustration.

The Court: Well, I have got to decide whether or not the pressure impulse used by the plaintiff

(Testimony of Samuel S. MacKeown.)

or the sound gun shot used by the defendant is the same thing. That is one of the things I have got to decide. It may not be the same thing in volume, but do they have the same properties, and are they measured by the same mathematical formulas.

Mr. Graham: Q. Dr. Mackeown, will you please compare the hot wire microphone used in defendant's apparatus with the pressure diaphragm of the Walker patent in suit 2,156,519?

A. The pressure diaphragm in the patent 2,156,519 that is Plaintiff's Exhibit 1, is a metal diaphragm which seals up the end of the tube, and through mechanical linkage and lever system operates a mirror to deflect a beam of light. There [350] is no electrical equipment in the recorder at all. It is purely a mechanical and optical system of recording. The hot wire microphone used by defendant it a device which changes the movement of air past it into changes in the electric current. It does it because the hot wire is cooled by any passage of air by the wire, and this change in resistance causes a change in the electric current flowing through the microphone. The changes are then amplified and they operate a recorder in which the paper is moved under a pen and gives a record of the changes of the air through the microphone.

Now, as Mr. Walker pointed out, the diaphragm disclosed in patent 2,156,519 is able to register both positive and negative pressure impulses. In other words, it can distinguish between a pressure wave and rarefaction. If you put it in front of

(Testimony of Samuel S. MacKeown.)

your mouth and blew on it you would move the diaphragm outwardly and that would result in, say, moving the beam of light to the right and giving you a deflection, let's say, to the right. That would be a positive pressure wave in the diaphragm. If you sucked in the diaphragm then would move inwardly and be deflected in the opposite direction, and the beam of light would move to the left. If we take the wire microphone and blow out on it, that causes a current of air to move through the diaphragm—well, if you blow on it it will be a current of air through the diaphragm which cools it. On cooling this wire, the resistance is decreased and the current will increase. [351]

The Court: Does that have electricity, just the natural electricity in it, or does——

A. From a battery, current is sent through this continuously and that is the thing that raises the temperature of it.

Mr. Graham: Q. There are two terminals on this hot wire microphone and they are connected by wire to a battery, are they not?

A. To a battery.

The Court: In other words, you connect that to electricity and they get red hot?

A. They get a dull red heat, yes. And when you blow on this it cools the wires and lowers their resistance, because as the wires cool the resistance is lowered, which allows the current to increase. If you suck in on this, it also causes a stream of air to pass through these and also cool it. In other

(Testimony of Samuel S. MacKeown.)

words, when any air goes through the microphone, no matter from which direction, it always cools; it never heats the microphone. So that there is no possibility of this microphone having the directional effect that Mr. Walker spoke about, and it responds in exactly the same way to the pressure wave as it does to a rarefaction wave, or it responds the same way to a positive pressure as it does to a negative pressure, and you can not tell from the increase in current whether it has been air going through in one direction or the other direction. [352]

Now, this microphone has, also, another very special feature, and that is that it responds to every change, if those changes are made slowly. If, however, we have rapid changes of the air going through here—if you whistle, then there will be a large number of changes of direction of this air, depending on the pitch at which you whistle. This microphone is not able to follow those rapid changes because there isn't sufficient time for the wire to cool down every time that the current of air changes and comes to rest and goes in the opposite direction. So that this responds only to very low frequencies and, consequently, a great deal of the disturbances, noises and other disturbances at higher frequencies will not be recorded by this hot wire microphone. They cannot give individual swings to your recorder. Furthermore, this microphone is connected to the amplifier through a transformer. This transformer is a very common elec-

(Testimony of Samuel S. MacKeown.)

trical apparatus which prevents very slow changes, changes occurring very slowly, to be effected. So by the use of this microphone and the transformer you have a device which can respond only to relatively low audio frequencies. And, furthermore, it is not affected by very gradual changes, changes of say less than one a second. Very slow changes cannot affect it because they cannot pass through the transformer. This microphone, then, has those differences. In addition, it has to be located in an entirely different position in the apparatus than what is [353] spoken of as a pressure microphone. This is not a pressure microphone.

The Court: You say a very rapid wave, or waves of rapid frequency, I guess you would say, are not recorded? A. Yes.

The Court: What do you mean by rapid? You gave us an instance of very slow, one a second.

A. Yes. Let us say we sound a note——

The Court: Well, take the gun sound from a bullet. Is that a slow——

A. That will have a mixture of frequencies, but the high pitched frequency would not be recorded.

The Court: It has low ones, too?

A. It has low ones.

The Court: Sufficient to affect that and record it? A. Yes.

The Court: Is the result of a hot wire microphone's inability to record or respond to high fre-

(Testimony of Samuel S. MacKeown.)

quencies, does that result in tuning out extraneous sounds?

A. Not tuning out. It does have the effect of not recording the extraneous high frequency sounds, very definitely.

The Court: But that would be the same as if you had an instrument that tuned them out, comparatively?

A. You would not get them. That is the result, you would not get the high frequency sounds. The method is [354] entirely different.

The Court: I understand. But if you did have one that would get the high frequencies, then you would have to tune them out, or can you tune them out?

A. You can tune them out or filter them out.

The Court: If you tune them out or filter them out the result would be the same?

A. Yes, that would have the same result, if you get rid of the high frequency noises. A great deal of the disturbances are kept out and not recorded, because of the inability of the microphone to follow the high frequencies. And you can adjust that by changing the size of wire. If you make your wire of finer material it can change temperature much more rapidly; and by having a very fine wire it will follow the higher frequencies.

The Court: Isn't that very fine?

A. Not nearly as fine as you can get it.

The Court: Really? I can't see it. The result

(Testimony of Samuel S. MacKeown.)

is that when I picked it up I stuck my finger through it. I think I broke the wire.

A. This is not fine wire as compared to the wire in electric light bulbs. Those wires have about 1/10th the size of a human hair. This is not a very fine wire.

The Court: Is that tungsten wire?

A. This is tungsten wire. [355]

The Court: Must it be tungsten wire?

A. No, it doesn't have to be. It must be some wire that will stand dull red heat without oxidizing. It may be nichrome or platinum.

The Court: Silver?

A. Silver would not operate at the temperatures at which this would run. Silver would soften or possibly even melt. But this hot wire microphone does not measure pressure. In other words, if this is put at the end of a tube it will not respond. A pressure microphone is put at the end of the tube and it responds, because at the end of the tube there is pressure, but there is no movement of air. The end of the tube blocks that. This must be put at the open end of the tube or have in back of it some space through which the air can pass.

The Court: In order to respond to the pressure?

A. It doesn't actually respond to pressure. It responds to the movement of air which may be caused by the pressure. It comes under the class of what we call velocity microphones, rather than pressure microphones. A carbon microphone, a crystal microphone, is a pressure microphone. This

(Testimony of Samuel S. MacKeown.)

is one that is called a velocity microphone, because it responds to the velocity of the air through it, rather than the pressure. Those, I think, are the main differences between the hot wire microphone and the——

The Court: But the pressure causes the velocity? [356]

A. The pressure causes the velocity; that is true.

The Court: So calling it a velocity microphone is just diagramming it down a little more?

A. There are a great many actual differences. For instance, this could not operate if it were located in the position shown in patent 2,156,519.

The Court: With the diaphragm?

A. With the diaphragm, because that is closed. You would have to put it at the open end of the tube, because it would be at the open end that you would have a current of air flowing by it.

Mr. Graham: Q. In other words, Doctor, the pressure diaphragm in patent 2,156,519 closes the end of the tube or pipe, which is indicated by the reference numeral 18. A. That is correct.

Q. So that a pressure impulse through this tube 18 impinges against this diaphragm and moves it?

A. That is correct; moves it slightly.

The Court: How much space do you have to have beyond that microphone to get the velocity necessary to cool the wire? Would the thickness of that frame in which it is placed be sufficient?

A. No, you would have to have a relatively large

(Testimony of Samuel S. MacKeown)

volume behind this in order to get enough air passing through there to get any appreciable cooling. In other words, if you have [357] this enclosed in a very small chamber there will be so little air passing through these wires—for instance, if I hold it in my hand, like this, and blow on it, there would not be enough air passing through that to get any appreciable effect.

Q. Wouldn't it depend on the pressure back of it? A. Yes.

Q. If you put a lot of pressure on, it would flow over the wire, and cause it to cool?

A. That would make it very insensitive. It would take a very large pressure to get a very small change. It would be made much more sensitive by having a chamber in back of it, so that the air could pass freely through the wires.

Q. So really it is a matter of degree; that is to say, the greater spread you can have in the space beyond, the more space beyond, the less pressure you would need to apply to get the same result?

A. That is true partially, and only partially, because the amount of air going through not only depends on the pressure, but the resistance that the pressure meets.

Q. I call the witness' attention to defendant's apparatus, and also to Exhibit J, which is a photograph of that apparatus. Will you point out to the court where the hot wire microphone is located, and what I call the bull nose behind it, allowing the passage of air through the microphone.

(Testimony of Samuel S. MacKeown.)

A. The microphone is contained near the union J-5 on [358] Exhibit J, and the red chamber behind it, J-6, is a chamber which allows an opening behind the microphone into which this air can move, and if this microphone were moved down to the end of this chamber it would be so insensitive you would get practically no response. It must be up in front of that chamber so there is some volume in which the gas passing through that can expand. That chamber is what the defendant refers to as the surge chamber.

Q. While this apparatus is before the court, is there anything between the hot wire microphone and the well which operates in any manner upon the echoes coming from the well?

A. No, there is nothing there which operates in any way upon the echoes.

Q. So that everything that comes from the well comes over the microphone?

A. All the disturbances in the well cause air to pass through the microphone.

The Court: What is this little handle down here.

A. That is a butterfly valve, which can be turned in a closed position to protect the microphone on the firing of the shot, if that is desirable, and open to allow the echo to get back from the well. The procedure would be to close that, fire the shot, and open it.

Mr. Graham: Q. Doctor, if that valve is closed, doesn't it destroy entirely the effect of firing the shot, on the [359] microphone?

(Testimony of Samuel S. MacKeown.)

A. No, it is a very loose-fitting valve, with a great deal of space around it so you can get air passing through it, even though it is closed. It is not a tight valve.

The Court: What is this?

A. That is the connection to the hot wire, and also to convey the change in current to the amplifier.

Mr. Mattingly: A complete description of that, your Honor, is in the supplemental answer to interrogatory 14, and the drawings and photographs that are attached to that. That is Exhibit 12-A, B, C, and D., I believe.

Mr. Graham: Doctor, will you compare the electric filter of defendant's Echo-Meter with the tuned accoustical resonator of the Walker patent, 2,156,519, Plaintiff's Exhibit 1, and first describe where the filter is located, and its connection?

A. The filter and its apparatus is located as a part of the amplifier, which may or may not be used.

Actually, what the filter is, is a circuit which is shown better on the schematic of the Echo-Meter electrical filter following page 13 of the manual, and it is incorporated in the amplifier and controls the response of the amplifier by means of preventing the amplifier from giving its maximum amplification, except at certain frequencies.

This adjustment that is made is simply moving certain resistances, and adjusting certain resistances by a very [360] simple manipulation, just the turn-

(Testimony of Samuel S. MacKeown.)

ing of a handle. These resistances are shown in the upper right. The lines with arrows on them indicate variable contacts that can be controlled by moving a handle, and by so doing they, in combination with the condensers which are marked as two lines up on the top, marked 2mu which stands for microfarads, give electrical measure of capacitation. That is the thing that is used to adjust the amplifier. It does not incorporate a resonant or tuned circuit. It is a Wren grid circuit, which gives a balancing effect at certain frequencies, so there is no response at that frequency. This then controls the amplifier and when you get no response to this circuit it allows the amplifier to have its maximum gain. Across this circuit you get a response then that operates at these frequencies to keep the amplifier from having its maximum gain. It is spoken of a as negative feed back amplifier, the negative part coming in to get the response when you don't apply anything to control it. This circuit is a balanced circuit; null in effect. When you get no response in this circuit then you are getting a maximum gain in that amplifier. That is just the opposite way in which a tuned or resonant circuit operates.

A resonant circuit operates to give you a maximum for frequencies which are produced, and this filter operates by balancing not by resonance, but by balancing, like a pair of scales, at a certain frequency. It is an electrical device [361] which has not in any way the properties or characteris-

(Testimony of Samuel S. MacKeown.)

tics of a resonant circuit, in the manner in which operates. Resonant circuits are extremely old. Th theory was first worked out by Lord Kelvin abo 1850. A filter circuit is relatively new, and wa first worked out by Dr. Campbell of the Bell Tel phone Laboratories in 1916. They have been use very extensively by the Bell Telephone Compan and make possible a communication of ten or twent telephone communications over two wires, so tha each party can communicate, and not be heard b the rest. That is entirely done by a filter. They ar entirely different from the resonant or tuned ci cuits, which cannot be operated that way. This an electrical device.

The tuned accoustical resonator as shown in pa ent 2,156,519 is simply a piece of tubing which ha a natural frequency corresponding to the lengt Every organ pipe uses just this. The way you g your notes from an organ pipe is by having a organ pipe of the proper length, so that it wi produce a note, and the pitch of that note is de termined by the length of the organ pipe, and tha is all. The accoustical resonator shown in pate 2,156,519 is just a piece of pipe which will respon to frequencies having a length proportional to th length of that tuned pipe. To change its respon you change the length of that pipe. That is a pur resonance circuit, and it operates on sound wave or pressure waves before they reach the diaphrag or microphone. Any [362] action it has is don prior to that, and it occurs in the gas of the pip

(Testimony of Samuel S. MacKeown.)

The electrical system, of course, cannot in any way affect what happens to the gas prior to its reaching the microphone or diaphragm, and can only operate on currents which are produced by the microphone.

There is another difference which should be pointed out: the adjustment of the tuned accoustical resonator in 2,156,519 patent depends only on the length of the tubing collar, which you wish to emphasize. It does not depend on the nature of the gas in the tubing; in other words, if we have the proper length for a 30-foot tubing that is proper and needs no adjustment no matter what is the pressure of the gas or what the velocity of the sound or pressure on that gas is; it makes no difference. That is always in adjustment because that tubing is filled with the same gas.

The Court: You mean the annular space?

A. The annular space is filled with the same gas that the accoustical resonator is. If you change it, you change the other exactly. You don't have to make any adjustment except for the adjustment of the length of the tubing collars.

Q. The lighter gases rise to the top, don't they?

A. In these wells usually you are having a flow of gas up there, and that keeps the gases pretty well mixed. If the well is not making any gas, then there will be lighter gas in the top than there will be in the bottom. [363]

Q. On the diagram, page 13, which, if any, are the connections with the hot wire microphone ap-

(Testimony of Samuel S. MacKeown.)

paratus? The circuit is through from this box c hot wire microphone to the recorder. Where do that circuit come in?

A. The upper portion of this diagram, with th arrow marked "filter circuit" is the filter circu itself. That is an entity down to the Jones plu The Jones plug then connects from the amplifie and the connections to the amplifier are shown i the lower part of the diagram. The diagram, i the lower portion is not the filter, but the ampl fier, and this is incorporated between the first an last stage of the amplifier, and at the left of th amplifier at the bottom is where the current fro the microphone, after passing through a tran former, enters the amplifier, at the arrow pointin to the left. We were discussing that as a gri circuit. That is connected to the grid of a radi tube. We have shown five radio tubes. That is th symbol for radio tube. There are five radio tub altogether. I will put a circle around the element which are the tubes. Those tubes with the circu connecting them form the amplifier.

The capability of amplifying a certain frequenc is determined by the adjustment of the contacto in the filter.

You have a control, called the volume contro very similar to the volume control on a radio, an that volume control is a manual control of th amount of amplification you get, and [364] th customary operation is that that will be set rela tively low when the shot is fired, and then grad

(Testimony of Samuel S. MacKeown.)

ually increased, so that you increase the amount of amplification you introduce into the system as the wave goes further and further down into the casing, and comes back. Those waves that have to travel any length are much weaker, so you can make up for the weakening effect of the waves traveling a long distance by continually changing and increasing the gain of your amplifier, and you can adjust that gain through an enormous range factor, 100 to 1,000, very easily and very quickly, and it allows the adjustment to the amplifier practically instantaneously for any size of impulse or sound that you are going to receive.

Q. There is nothing new about that?

A. No, it is very old.

Q. You have referred to the term "tuned accoustical resonator" of the Walker patent. Would you please designate whether that is a factor of the Walker patent, so as to tie up with your testimony.

A. The tuned accoustical resonator is a pipe extending from the casing through the coupling 19, and on through to the diaphragm itself. It is the length of that pipe which is actually the accoustical resonator.

Q. And that has its effect on the waves or echoes prior to the time they reach the diaphragm of the Walker apparatus?

A. Yes, it has its whole effect before anything reaches the diaphragm. [365]

Q. This electrical filter and this amplifier you

(Testimony of Samuel S. MacKeown.)

have been referring to are located so that they have effect on electrical impulses after those impulses have been generated or inaugurated by the hot wire microphone? A. That is correct.

Q. So that the operation of the accoustical tuner of Walker and the electrical amplifier and filter of defendant's device are entirely unlike in their mode of operation, is that correct?

A. Yes, they are entirely different in their mode of operation.

By the Court: One is electrical, and one is manual or mechanical?

A. There are a great many more differences than that. It is possible to have an electrical resonator which would be a close imitation of this, and still would be electrical and not accoustical.

Q. I don't mean that judicially. You say that the filter, this thing you have just been describing, operates on a tuned wave length, the electrical filter?

A. No, the electrical filter does not work on a tuned wave length.

Q. The mechanical apparatus 2,156,519 operates on a tuned accoustical resonator? [866]

A. That is correct; it operates on a filter principle.

Q. I thought you said a while ago—I wrote it down—that a filter operates on a tuned wave length.

A. No, I am sure—at least I hope I did not say that. The filter operates actually as a balance.

(Testimony of Samuel S. MacKeown.)

When two impulses are weighed they are found to be the same. That affects the gain of the amplifier in such a way as to allow that frequency to go through. The actual filter circuit is a weighing circuit which balances the effect in the two parts of that circuit, and when they are weighed and found to be the same effect, that regulates the control in the amplifier.

Q. A filter operates on an electrical wave length?

A. Yes, I think you could say a filter operates on an electrical wave length. I want to point out that there is a big difference in resonance and filter. You can have an accoustical resonator and an accoustical filter. They are very different. Mr. Stewart did a lot of work on an accoustical filter which is not a resonator.

Q. You can have an electrical resonating circuit?

A. Yes, and a filter circuit, and they are entirely different.

Q. Then the defendant's apparatus translates the pressure impulse, or the result of the pressure impulse into electrical wave lengths, and records them, whereas the plaintiffs' does not?

A. I would say, rather, electrical frequencies than [367] wave lengths.

Q. Frequencies? A. That is correct.

Mr. Graham: Q. I call your attention again to Exhibit 1, patent 2,156,519. Do we have on our Echo-Meter, defendant's device, a pressure responsive device?

(Testimony of Samuel S. MacKeown.)

A. No, we have no pressure responsive device at all. We have this hot wire microphone, but that is not a pressure responsive device, and does not respond in the way that the pressure responsive device described in that patent is required to. In other words, that patent requires that the pressure responsive device be able to distinguish between a pressure wave and a rarefaction wave, because this patent speaks of the desirability of being able to distinguish these different kinds of impulses. In the Echo-Meter there is no device which is able to distinguish between a rarefaction wave and a pressure wave, and it hasn't any essentially characteristic pressure responsive device.

Q. State whether or not defendant's device has a means for registering the pressure variations produced in a well.

A. No, I don't think it has, because, again, it cannot register the positive and negative pressures, nor the pressure wave as against a rarefaction.

It is incapable of giving this distinctive recognition to a pressure wave and a rarefaction wave. It does measure [368] the flow of air or gas past the microphone that results from pressure variations, but it loses the sense of direction.

The Court: Then I understand you to say that the defendant's apparatus does not record any negative—rarefaction?

A. It records that exactly the same way as it will a pressure. It will record it, but there is no way of distinguishing between that and a pressure

(Testimony of Samuel S. MacKeown.)

wave. You remember, if I blow through it I will cool it; if I suck through it I cool it. And I get the same kind of response on both. Whereas, your pressure responsive device gives me a different one.

The Court: Well, counsel, this question arises by virtue of Exhibit 11-B, the chart. Calling your attention to Plaintiff's Exhibit 11-B; that happens to be a record which was made by an echometer in an oil-well; is that correct?

Mr. Mattingly: That is correct, your Honor.

The Court: I understood from your testimony yesterday that this is the atmospheric pressure of the axis, which should be a straight line, that the positive, or all the pressure waves would record above or to the right of the axis, and the negative or rarefaction waves would record to the lower or left of the axis. A. That is correct.

The Court: On this strip the very first variation in the axis comes to the left, then it crosses the axis to the right. Likewise the second. Likewise the third. Likewise [369] the fourth. And there are only four major variations in the line of that axis, each of which varies first to the left. And, as I understand your testimony and Mr. Walker's testimony, that is the recordation of a rarefaction wave; is that correct?

A. That is correct. May I explain why that is so?

The Court: Yes. That is what I want to know.

A. That is because there are transformers—these things that you were worried about—these trans-

(Testimony of Samuel S. MacKeown.)

formers in the circuit which prevent the base line going through, and all you get are variations, so that you do not know in this method whether the variations are above the line or below it. And if we connected directly in an amplifier to the response and had a current which flowed through the hot wire, these would only be on one side of the line and not on both sides.

The Court: If what?

A. If we measured and recorded directly the current through the microphone, without going through the transformer, then all of these would be on one side of the base line.

The Court: Why does putting them through a transformer record them on both sides?

A. Because the transformer wipes out the position of the base line and you don't know where the base line is.

The Court: So that this does not give us any reading at all of expansion in the annular space?

A. That is correct. For instance, if the pressure in the [370] chamber were increased it would not shift in any way this base line. If you just deliberately pumped in double the amount of gas in there, your base line would still remain the same, although you double your pressure in there, because this change was made so slowly that it would not get through the transformer. The transformer prevents those very slow changes from being recorded.

The Court: Then you cannot tell from this record, or any record made from defendant's appara-

(Testimony of Samuel S. MacKeown.)

tus, for instance, when you have passed through the liner top and entered the perforated casing again?

A. Not from the direction.

The Court: Not from the direction of this?

A. No.

The Court: You can go through something else in here?

A. No. You have no way of distinguishing that, except by position.

Mr. Babcock: It records, does it not?

A. It records the kick, but it doesn't give a different kind of kick.

The Court: But what I mean, you cannot tell from reading this where it is; is that right?

A. You get a kick, and from the position of that kick on the tape, how far it is from where the shot started, you can identify what it is. That is the only method. [371]

The Court: If you can identify that it is a perforated casing you can tell from reading this where it is?

A. That is right; if you know it is a perforated casing.

The Court: If you know in advance?

A. Yes.

The Court: But all you know is that there is something there? A. That is right.

The Court: Or a stoppage in the hole or a cave-in? A. That is right.

Mr. Babcock: Q. I thought you answered the

(Testimony of Samuel S. MacKeown.)

court wrong. The court asked if kicks to the left on that chart indicate rarefactions?

The Court: He said they do not. Now, let me see if I understand you correctly. All this record shows is obstructions. It does not indicate whether they are contractions or expansions in the well?

A. That is correct.

The Court: That would record any rarefaction waves as rarefaction waves——

A. That is correct.

The Court: ——because you have no axis here? In other words, this is an arbitrary line?

A. That is exactly right.

Mr. Graham: Q. Dr. Mackeown, will you state whether [372] or not in the defendant's apparatus there is any means having a natural frequency of oscillation so related to the frequency of the echoes from a tubing coupling as to accent the registration of those echoes?

A. Well, there is nothing in the defendant's apparatus that has a natural frequency of oscillation, at all. The filter circuit does not. And there is nothing that accents the tubing collar reflections in the sense that I understand that is used in the 2,153,519 patent to describe the operations of the accoustical tuning. That is described on page 5, column 1, starting at about line 40. I might read just one sentence, starting at line 48.

"As will be understood, the introduction into a sound wave or multiplicity of sound waves of another wave tuned with one of the waves, produces

(Testimony of Samuel S. MacKeown.)

a beat or amplification of certain of these waves differing in frequency from the first wave will be damped out."

I don't quite understand that sentence myself. I do understand what accoustical tuning is, but there is no such operation in any part of the defendant's apparatus. There are no other waves created and no beats produced.

Q. Will you state whether or not defendant's apparatus has any resonance means associated with receiving and registering means to produce therein a natural accoustical period of oscillation. [373]

A. There is no resonance means at all, and it has no possibility of having any accoustical period of oscillation.

Q. Will you state whether or not defendant's apparatus has any means to accent tubing collar echoes?

A. Well, if "accent" is used to define the operation of the resonance circuit, it does not have that kind of operation. It does have an amplifier in it. The amplifier has a control on it which can be varied, and in that way you can increase or control the amplitude of these echoes that you receive by manually changing that volume control. And in addition it has this filter, but the filter does not accent anything in the sense that—the only thing the filter does is cut down the response. It cuts down all responses, but it cuts down the responses in the region you don't want more than it does the others. But the filter does not amplify. It cuts everything

(Testimony of Samuel S. MacKeown.)

down, but it cuts the unwanted parts down more than the wanted parts.

Q. I direct your attention to patent, 2,209,944, being Plaintiffs' Exhibit No. 3, and ask you to compare the methods of this patent with the methods used by defendant.

A. Well, both the defendant's patent and this patent fundamentally have a method of locating surface levels by using either a pressure impulse, sound wave or sound impulse, and in recording that sound impulse. But in the method disclosed in this patent 2,209,944 the magnitude of the pressure [374] impulse, its characteristics are explained, or the patent states that these must be adjusted so as to bring out the distinguishing characteristics and to get the necessary response.

Q. Where is that in the patent?

A. It is in a number of places. For instance, on page 3, at column 1, starting at line 46, the patent states:

> "The only item which must be provided for is that of producing a pressure wave echo of such magnitude and of such character that the echo from the tubing catcher can be distinguished from the echo received from the fluid surface."

And throughout the patent I can refer to a number of places, there are four or five places where this is emphasized.

This is not necessary in the apparatus used or the

(Testimony of Samuel S. MacKeown.)

method used by the defendant, for several reasons. First of all, it is not possible to get the distinguishing difference on the defendant's apparatus. Then, again, it is not necessary to adjust in any way the character or magnitude of the sound wave or sound impulse that is used, provided only that it is strong enough to get the desired results. If it is stronger, if you increase it, you take care of it immediately by decreasing the gain on your amplifier. If it is weak, you increase the response by changing the gain on your amplifier.

The Court: I don't understand the latter part of your answer. You say it isn't necessary to determine the location of [375] the tubing catcher?

A. It isn't necessary, in any of the methods used by defendant, to adjust in any way the magnitude of the impulse that is introduced into the tube——

The Court: In order to determine where the tubing catcher is?

A. In order to determine anything. You will get the same record.

The Court: You get the same record from a tubing catcher as you do from a tubing joint?

A. Yes, you will get the same record if you use a weak impulse and increase the gain on your amplifier as you will if you use a strong impulse and decrease the gain on your amplifier.

The Court: From the tubing catchers?

A. From everything. You will get exactly the same record all the way down; exactly the same strip; you couldn't tell the [376] difference.

(Testimony of Samuel S. MacKeown.)

The Court: Then you can't tell where the tubing catcher is from your record?

A. Yes, you can tell where the tubing catcher is, because the tubing catcher will give a relatively large kick, compared to the tubing collar echoes.

The Court: I see.

A. But not by the direction of the kick.

The Court: I think I understand.

A. The only thing you want on the record of the Echo-Meter is to have a record of all of the variations which will be large enough to be recognizable and not so big that it will go off the paper. Consequently, you use a shot that will travel down as far as you want it to go and have the echoes come up. You don't have a shot that has any peculiar characteristics or there is no adjustment of the shot or anything of the kind; just one that will be big enough. It may be a big shot. Sometimes a small shot will do.

The Court: Does the length of the pipe ending in the surge chamber and beyond the microphone, does the length of that pipe have anything to do with the working of the apparatus?

A. Well, that pipe is a very short pipe. It is so short that it does not work well for the reflections that come from the well. That is too short. There could be, in back of the microphone, an accoustical resonator, which would improve very [377] decidedly the effect that you would get from using this. In other words, it would be possible to include the accoustical resonator shown in patent 2,156,519, in

(Testimony of Samuel S. MacKeown.)

back of the microphone, either by using a tube, which was some ten feet long, or some such size as that or by using what is known as the Helmholtz resonator. The prior art shows a beautiful example of that. And you could use an accoustical resonator in back of this, but that is not done.

The Court: Does the distance from the hot wire microphone to the end of the surge chamber have any relation to the measurements that are made by this whole apparatus?

A. Yes. If you increase that chamber, you will, in general, increase the sensitivity of this microphone.

The Court: I am not speaking generally now. I have in mind that the plaintiff says a piece of tuning pipe has a definite relation, or will work better, if it has a definite relation to the tubing length.

A. Yes. This would have exactly the same effect as the accoustical resonator would have.

The Court: One-half?

A. One half would be satisfactory.

The Court: That would merely increase the efficiency of the apparatus, or is it necessary to have that for the apparatus to give a definite response?

A. It would do much more than increase the efficiency of the apparatus. It would then, by making use of an [378] accoustical resonator, as shown in patent 2,156,519, give you the selective action of the accoustical resonator if you included the accoustical resonator in the end.

(Testimony of Samuel S. MacKeown.)

The Court: But the one shown here is a commercial apparatus, I take it?

A. That is true.

The Court: But this one that is shown here, the length from the end of this surge chamber to the end of the hot wire microphone, that length has no relation to the tubing length in the well which is used to make it?

A. No. The fact is that that length is such that all it does is emphasize and is resonant to certain disturbances.

The Court: Accents them?

A. Accents them as in the terms used in this patent except it is a resonator for a disturbance which does not want to be measured, a disturbance which would be approximately three or four times this long. In other words, I think we can say the Echo-Meter has deliberately avoided using a tube on the back end of their microphone which in any way could be said to be an accoustical resonator. That could be used in connection with all the rest of their equipment and would give a better response.

The Court: You can have this pipe here beyond the microphone any length?

A. You could have. [379]

The Court: And still get the same results you get now; is that correct? It might be only six inches long or it might be only two feet long, say six inches longer than it is? Would that affect the results obtained now by this apparatus?

A. Yes. The shorter the pipe is or the shorter

(Testimony of Samuel S. MacKeown.)

the volume of that cavity enclosed by the pipe, the lower will be the sensitivity of your microphone, because there isn't the space in back of that microphone for the air to get into it.

The Court: You are speaking scientifically now, and accurately. I am speaking generally from the view point of recording obstructions in the well. Would it still record obstructions in the well if this were six inches shorter or six inches longer?

A. Yes.

The Court: It would record them with approximately the same kind of record?

A. With approximately the same kind of record.

Mr. Mattingly: Your Honor, we have the Depthograph apparatus in court this afternoon. We have it connected up with the gas bottle so that we can demonstrate the manner in which it operates.

The Court: I will come down and look at it. Will you demonstrate it down there?

Mr. Mattingly: This pipe represents the pipe No. 18, shown on patent 2,209,944, and is part of that long tube or pipe that goes in the well, and in actual installation in a [380] well this pipe would be connected through a long pipe to a well casing-head, somewhat similar to that pipe, on the casing-head, which would be some 10 or 15 feet away from the apparatus as it is setting here on the floor.

The Court: I want to see what the pressure impulse does, whether or not it makes a noise.

Mr. Mattingly: That is what we can demonstrate.

(Testimony of Samuel S. MacKeown.)

The Court: How much pressure do you put in there when you shoot a well?

Mr. Walker: The pressure ranges from around 10 pounds up to over 500, depending upon the depth of the well and size of the casing.

The Court: Well, a well 3,000 feet deep?

Mr. Walker: 3,000 feet deep with an 8-5/8 casing, about 100 pounds.

The Court: All right, let's try that.

Mr. Mattingly: That would be a hundred pounds, as compared with the pressure existing in the well.

Mr. Walker: A hundred pounds' difference.

The Court: All right. Let's try it with a hundred pounds first. You have a hundred pounds now. Open that up.

(Illustrating with apparatus.)

The Court: Now, put in 250 and open it up. Is that 250 now?

Mr. Walker: Yes. It is dropping down a little bit; leaking through the valve slightly. [381]

The Court: All right.

(Illustrating with apparatus.)

The Court: What is that gas?

Mr. Walker: Just natural gas. It is harmless.

The Court: All right.

Mr. Walker: Now it is 500 pounds.

The Court: You have got 500 pounds now. All right.

(Illustrating with apparatus.)

Mr. Mattingly: Your Honor, we have here this

(Testimony of Samuel S. MacKeown.)

long piece of pipe which you have been inquiring about. That is fitted to take either the pressure gas from the gas bottle or can be fitted with a gun similar to that of the defendant's device. By that we can compare the relative sounds between the two. On this piece of pipe we have the arrangement to be connected to a gun apparatus corresponding to the type of gun used by the defendant, and it may be interesting to compare the noises of the two pieces.

Mr. Walker: We will not compare noises. We will compare gas volume generated by a shell and gas volume used for testing a well.

The Court: What is this going to be, now?

Mr. Walker: A comparison of the volume of gas directed into a well by a cartridge with the volume of gas which we inject with this equipment.

The Court: Not a comparison of sound? [382]

Mr. Walker: No, that isn't what we are doing here; the cartridge creates such an awful smoke and smell I don't want to discharge it into the room.

The Court: All right.

Mr. Walker: We will first discharge gas into this tube, which is six feet long and two inches inside diameter, and see what pressure it builds up in there. We will take a quantity of gas used in an average well, we will say, 200 pounds in the chamber, then we will take that and discharge the cartridge in there and see where the gauge goes to.

The Court: I see. Can you see where the gauge goes to?

(Testimony of Samuel S. MacKeown.)

Mr. Walker: It is a little difficult to see where the gauge goes to from here.

The Court: Yes. Well, it will be recorded.

Mr. Walker: Now the chamber is filled with 100 pounds, and we discharge it into this 6-inch pipe, and see what the pressure is raised to.

Mr. Smith: The movement is pretty well damped.

Mr. Walker: It is damped by partially closing this valve. What does that read?

Mr. Smith: It reads 35.

Mr. Walker: We will remove the gas chamber and put on the gun and fire a 10-gauge shell into the same tube.

Mr. Mattingly: The piece being attached at the present time is one of the Winchester salute guns, is it not? [383]

Mr. Thomas: A salute gun.

Mr. Mattingly: That is the type of gun referred to in defendant's supplemental answer to interrogatory No. 14?

Mr. Walker: That is right; a 10 gauge cartridge made by the Western Cartridge Company, and a blank cartridge; I believe the same as defendant has in their equipment box in the room. You will have to watch the gauge closely, because the explosion of this powder creates a gas which is heated to a very high temperature as it is generated and the pressure gauge will go up quite high, and as the piece of pipe cools the gas it will cause the gas to contract, and the gauge will drop quite rapidly until it gets down

(Testimony of Samuel S. MacKeown.)

to 25 pounds, where the gas and the tube reach the same temperature.

The Court: Are you ready. What did that register?

Mr. Walker: It registered about 85 pounds. It is a matter of damping of the valve ahead of the gauge. We have damped that in such a way that we are sure that it does not overshoot. It does not indicate any higher pressure than that which is generated.

The Court: What is that yellow thing on the gauge?

Mr. Walker: That is just something to look at, because the damping valve was set so that the pointer reached approximately that point, and keeping the eyes on that position on the gauge you can tell very closely to where it reverses.

The Court: That was about 75.

Mr. Walker: It has been settling back almost stopping [384] at 30, and is practically stationary at 25 pounds, after the gas and the tube reach the same temperature.

The Court: What is stationary?

Mr. Walker: The pointer, the pressure gauge.

The Court: It is stationary at 25?

Mr. Walker: Yes.

The Court: Did you observe that, Doctor?

Dr. MacKeown: I did not notice when it came back.

The Court: He explained that the heat caused it

(Testimony of Samuel S. MacKeown.)

to go up and to come back and to remain stationary at 25.

Dr. MacKeown: I am satisfied with that.

Mr. Walker: The more we fire the more foreign matter accumulates in that valve down there, and it leaks, so it is liable to leak down lower than 25. There is also leakage at this end, past the shell.

The Court: Is there any question about these gauges, their accuracy?

Dr. MacKeown: These two gauges are relatively correct. I am satisfied with it.

The Court: Have you any questions you would like to ask while this equipment is here?

Mr. Graham: Not other than I might ask you—you do not claim that your patents in suit cover the mere firing of a shell or the introduction of a pressure wave from this cylinder in the well, do you?

[385]

Mr. Mattingly: Not that alone.

The Court: Is there any ratio of increase in the pressure, say in your 6 feet of pipe with the pressure of gas released into the pipe; in other words, 150 pounds produced 35 pounds on the gauge. Suppose you put 500 pounds in there, would that be approximately three times that?

Mr. Walker: Approximately, your Honor; approximately three times.

Mr. Graham: Q. Dr. Mackeown, are you familiar with the method of measuring sub-surface pressure, using the method employed in figure 2 in

(Testimony of Samuel S. MacKeown.)

front of page 52 of the manual defendant's exhibit 11-C?

A. Yes, I am familiar with the method shown in that figure.

Q. Does the method illustrated on that Figure 2 of Exhibit 11-C require a knowledge of density?

A. No, it is not necessary to know or determine the density of the fluid in the annular space to calculate the sub-surface pressure by this method.

Q. Will you please explain the method illustrated there on Figure 2.

A. This method is based on taking measurements of the fluid level at two different levels when the production rate is maintained constant, reading the casing head pressure, and from these readings, calculating the casing head pressure, which would be necessary to depress the fluid in the annular [386] space down to the desired surface at which you wish the pressure; that probably would be the pump. By this method of calculating the casing head pressure which is required to actually move all of the fluid down to the level of the pump, and out of the casing. Then the height of the fluid level, under those conditions, is zero so that the density of the fluid is not determined, or does not enter into the calculation.

You have a condition then, where you have depressed or calculated casinghead pressure necessary to depress the fluid right down to the pump, so the height in your fluid column is zero, and you do not take into account or use the density; you simply take that casing head pressure and add to it the

(Testimony of Samuel S. MacKeown.)

weight or the pressure exerted by the column of gas in the annular space and that gives you the pressure at the surface.

If we refer to the formula on page 35 of the manual, which has been used before, spoken of, which reads—this is marked formula 1 on page 35 of the manual, which reads: "that the bottom hole pressure is equal to the pressure at the casinghead plus pressure of the gas, plus the height of the fluid column, times its density"—that formula is correct, but, in this case, you see, our height was zero, so the last term does not add anything, and we don't have to know what the density is. You apply the same formula, you have calculated the condition where your fluid level is zero. You don't have to know the density. [387]

Q. You have referred in this manual to finding two fluid levels. Does that method include the determination of pressure on fluid surface at those two levels?

A. No, it does not. This method includes only the determination of the pressure at the casinghead, which is read on the gauge. The pressure on the fluid surface in those two cases would not be casinghead pressure, but would be that casinghead pressure plus the pressure exerted by the column of gas. In this method you do not calculate the pressure on the surface, but only the pressure existing at the top of the column of gas, where the weight of the column of gas does not enter in. And the weight of the

(Testimony of Samuel S. MacKeown.)

column of gas above either one of those two fluid levels is not taken into consideration.

The Court: You mean you do not add that at all?

A. You add that at the bottom, but you do not add at the level at which you make the measurements.

Q. That is taken into consideration?

A. No, your Honor, it is not. This is based on the theory that the liquid column will be depressed the same amount as you increase the pressure at your casinghead. If I increase my pressure at my casinghead by 100 pounds and thereby depress the fluid level 50 feet, this is based on the theory that for every 100 pounds of increase in pressure it will decrease it 50 feet. It does not take into account the pressure at the fluid level, but the pressure at the casinghead; and then when you [388] come to calculate the casinghead pressure sufficient to depress the liquid to the bottom you have to add a correction for the pressure exerted by the gas the whole length of the column to give you the actual existing pressure at the bottom of the hole or the pump.

Q. Would you take the pressure of the fluid at that level?

A. We would take the pressure of the fluid at that level if you ever had that level there.

Q. And if there was any fluid.

A. And if there was any fluid.

Q. How does that give you the pressure? You have got your formula here? A. Yes.

(Testimony of Samuel S. MacKeown.)

Q. That proves it to you who know something about it; how does it prove it to me?

A. We apply the same formula. The pressure at the bottom of the hole is made up of three parts. One part, the casinghead pressure, which is used on the gauge at the top. That might be 300 pounds. That is the gas pressure at the top of the hole, where the gauge is.

Q. Isn't that pressure all the same all the way down?

A. No; because as you go down in the hole you have in the gas column the weight of the gas.

Q. I mean excluding the weight of the gas. The casing- [389] head gas pressure is the same in the annular space all the way down, isn't it?

A. The casinghead pressure is only the pressure at the head of the casing. Then as you go down in the casing, the pressure increases all the way down only by the weight of the gas.

Q. Then excluding the weight of the gas, the pressure in this annular space is the same from the top of the well, or the casinghead, to the top of the fluid?

A. That is correct.

Q. Then you add the weight of the gas?

A. Yes.

Q. So that your casinghead pressure, if it is 300 pounds, eliminating the weight of the gas would be 300 pounds on the fluid level?

A. That is correct. To answer your question, in this formula, since you have calculated the casing-head pressure when your height is zero, to find the

(Testimony of Samuel S. MacKeown.)

actual pressure existing, you take and calculate the casinghead pressure to give you zero height, and add to that the column of gas.

Q. That is Pg?

A. That is Pg. That is the weight, the pressure due to the column of gas.

Q. Then it would be identically the same if you took the pressure on the fluid level and added the weight of the [390] column of gas, wouldn't it?

A. The pressure on the fluid level has the weight of the column of gas included in it.

Q. What I am trying to understand; you expressed right here a casinghead pressure?

A. Yes.

Q. The plaintiffs have been talking about pressure on the fluid surface? A. That is correct.

Q. You are talking about the same thing?

A. No, we are not.

Q. It is the identical factor?

A. No; the pressure in Los Angeles is different than the pressure at Mount Wilson. The barometric pressure, the ordinary pressure in your gas, is lower at Mount Wilson because Mount Wilson is higher. On top of Los Angeles there is a column of ordinary air extending 5000 feet up in the air, which is not present at Mount Wilson, so our pressure here is greater. The pressure at the fluid level is the same as the pressure at the casinghead plus the column of gas.

Q. How do you tell what the pressure is at the bottom of the hole?

(Testimony of Samuel S. MacKeown.)

A. The pressure at the bottom of the hole is the pressure required at the casinghead to depress the liquid to the bottom of the hole plus the pressure of the gas column at the bottom of the hole. [391]

Q. That is something that you know?

A, That you can calculate; plus zero for the last term, because the height of your fluid column is zero.

Q. I think I understand it now. In other words, the pressure at the bottom of the hole is the amount of pressure which is exerted by the introduction of whatever you use to increase the pressure at the casing head, which likewise increases the pressure on the surface level the identical amount?

A. Yes.

Q. And so many pounds per lineal feet of the weight of the gas?

A. Yes. It is not quite uniform, your increase in your gas column. It is not proportional to the depth. In other words, the first 100 feet of gas do not add the same amount of weight as the second 100 feet; the second 100 feet add a greater increase.

Q. On this chart at 3980 feet the casinghead pressure is 18 pounds per square inch?

A. Yes. That is in a stable pumping condition.

Q. In other words, that is without any increase or decrease, just as the well is pumping?

A. Yes.

Q. Then you add 100 pressure to increase to 130 pounds? A. That is correct. [392]

Q. Then you measure the fluid?

(Testimony of Samuel S. MacKeown.)

A. That is correct.

The Court: Then, that is the last measurement you take?

A. That is the last measurement that you take.

The Court: So that you extrapolate those figures to the additional place where the pump is located——

A. That is right.

The Court: ——by measurement of a known factor, and you get the pressure at the pump at 4890 feet; is that right?

A. That is an extra measurement that has been made in this case.

The Court: You wouldn't need to do that?

A. You wouldn't need to do that. The other two points would determine the straight line.

The Court: Down here you have got "Casinghead pressure 258 pounds. Gas column 42 pounds".

A. The bottom of the well is at 5125 feet, and if you read from the curve, the casinghead pressure which would be necessary to depress the fluid to that is 258 pounds. You see, at the bottom of the scale in the abscissa, is between 200 and 300. So you can read from that scale that intersects with that line at 5125, which would be 258 pounds. That gives you the casinghead pressure necessary to depress the liquid to the pump level. Then to find the true pressure you add the weight or the pressure exerted by the gas column all the way down, which calculates out to be 42 pounds. [393]

The Court: I think I understand the formula.

(Testimony of Samuel S. MacKeown.)

Mr. Graham: Q. Now, Dr. Mackeown, will you take the Batcheller patent 602,422, that is defendant's exhibit O-2, and compare it with the patent, 2,156,519 in suit?

A. This apparatus is best shown in Fig. 3 of the Batcheller patent. The purpose of the Batcheller patent is to find obstructions in tubes, primarily pneumatic tubes, such as are used for carrying mail and packages. Unknown obstructions. You don't know where they are and want to locate them. And that is accomplished by firing a revolver, a blank cartridge, from a revolver which is shown at K, into the tube; and the sound impulse hits the obstruction, is reflected back, and then travels through the tube H^{12}, through the valve H^{13} to the mechanical recorder which is shown as H^{11}, where it makes a mark on a smoked piece of paper. The diaphragm and its mechanical linkage is shown enlarged in Fig. 4. The diaphragm is shown as H^6 and it operates a lever mechanism which is marked H, ending in a stylus which is h, and that small stylus makes a mark on the paper. They way it makes this mark is shown in Fig. 1.

In Fig. 1 is shown the way this stylus is actuated by this pressure diaphragm, making a record. It is shown in the lower left of that picture. To the right of that is a [394] timing device actuated by a clock mechanism, which is shown in Fig. 3 as G^8, a pendulum which swings, and every time the pendulum reaches its lowest point it closes a contact and that moves a stylus G^4 and, in addition, a

(Testimony of Samuel S. MacKeown.)

timing record is made by the tuning fork F. So we get a resultant record shown in Fig. 5, where the marks n^1 and n^2 are caused by the stylus *h* on the pressure diaphragm. The mark n^1 marks the time at which the gun was fired, and the mark n^2 is the record from the echo from the unknown obstruction. The mark on the right of that marked L is caused by the clock or pendulum, and indicates time in half-second intervals. The curve in the center is traced by the tuning fork, which is set to be operated, for instance, at 512 cycles. That is the frequency of "C", high-C, in the audible range.

Q. State whether or not this patent, at the time of this invention of Batcheller, recognized the fact that the rest of it was old, that is, as far as the shot and making an echo, and return of the echo and receiving it against the diaphragm?

A. Yes. It states so in that paragraph starting at line 17, page 1. You asked me to compare this with patent 2,156,519. This uses the same type of mechanical recorder that is used in the apparatus of the patent 2,156,519. There is no microphone or electrical equipment employed, but a [395] pressure diaphragm which operates through a mechanical leverage system to produce directly the record. Of course, the apparatus in patent 2,156,519 will use a light beam and photographic strip instead of the smoked paper.

This apparatus uses the firing of a blank cartridge to produce the sound impulse, which is different from the type of impulse employed in the

(Testimony of Samuel S. MacKeown.)

patent 2,156,519. There the impulse is produced from a gas chamber. The type shown in the Batcheller patent, where a blank cartridge is fired, is the type of sound impulse employed in the defendant's apparatus.

Mr. Graham: Q. Now, Doctor, will you take the Fessenden patent 1,240,328, Defendant's Exhibit O-4, and compare that with the 2,156,519 patent in suit?

A. This Fessenden patent is important only because it shows the use of sound waves and the reflection of sound waves for measuring the distance to an unknown object without having to know the velocity of the sound waves or measuring the time, or lapse of time for those sound waves to travel their path. It is done simply by comparing the distance, and no measurement of velocity of sound waves or lapse of time is necessary. The arrangement that Fessenden uses as shown in Fig. 1, in the lower right-hand corner, is a shallow drill hole, and in each corner is a drill hole which is filled in with water.

The Court: Which is the drill hole? [396]

A. The drill holes are 11, and are shown in Fig. 2 in perspective. The drill hole in Fig. 11 in the lower right hand corner, 14 in the upper right-hand corner.

Q. In other words, in Figure 1 you are looking down on that just the same as a circle, and in Figure 2 that is as though you cut it down through the ground and saw the actual hole in the ground?

(Testimony of Samuel S. MacKeown.)

A. These drill holes are laid out at a known distance which, in the patent, is said to be five miles, and a source of sound is introduced in one of these, and is shown introduced into the drill hole 11 by means of a generator or oscillator which is actuated by the key 41. Now, if this sound is produced in the hole 11 it travels in a straight line to each one of the receivers, and makes its mark.

Q. That is, it travels through the wires on the surface?

A. The electrical impulse travels through wires and makes it mark, and in addition the sound travels to the receiver and makes a later mark on that, because sound travels relatively slowly.

Q. Through the earth?

A. Through the earth. It is indicated as traveling through the line 59, along the path 59 to the receiver 18, and that makes another mark on that recorder which can be used to represent the distance on the record required for this sound to travel the known distance on the record required for this sound to [397] travel the known distance between those two which, say, is five miles.

Q. It has first been recorded at 15 in the hole 11? A. Yes.

Q. Does there have to be water in this hole?

A. There has to be some means of transmitting this sound wave effectively from the sender to the ground. This is a travel through the ground. In addition another sound wave may go out and hit such a body, as an ore body, as the body 44, and

(Testimony of Samuel S. MacKeown.)

that will be reflected up to the receiver 18 in hole 14, and also reflected back to the receiver in the hole 18 where the sound originates. The receiver is 15 in the hole 11, where the sound originated. By recording the arrival of the sound Fessenden can locate the distance of this body 44 from two holes, and thus find its location in space, in the ground. He compares the time of return of 15 with the time to 18, and the time along 59.

The only point I think in this patent is that this is a method of using sound in a medium of which the velocity of sound is not known; that is, in the ground, to measure distance without the necessity of measuring time or knowing the velocity.

Mr. Graham: Q. How does that last statement of yours compare with the defendant's method?

A. The defendant uses that method, because it measures the distance of either lengths of tubing, or the distance to [398] some obstacle, such as tubing catchers, and from that distance or record, it uses that to calibrate in terms of distance, and can directly determine the distance to the fluid surface without the necessity of measuring the velocity of the sound in the gas or the elapse of time in that gas. It is not necessary to do that. You can follow this method of Fessenden, in which you simply calibrate your instrument in terms of a known distance.

Q. I will ask you, Doctor, to discuss the Tucker patent, 1,351,356, entered as Defendant's Exhibit O-5, with patent 2,156,519.

(Testimony of Samuel S. MacKeown.)

A. This Tucker patent, which is Exhibit O-5, is a description of the hot wire microphone used in the defendant's apparatus. It is also a description of a tuned accoustical resonator used in combination with that microphone to give the characteristic resonance response that you get from the resonance action, and to make the microphone, when so used, particularly responsive to certain frequencies.

The microphone itself is shown in Fig. 4, where you see the fine wires used in the hot wire microphone, and the wires are marked *m*, and air passing through these wires which are heated cools them and allows the current to increase, and it is this variation of current which is amplified and recorded. This microphone was developed for locating gunfire, and in the article by Tucker, which will be referred to, it shows [399] that he was a Major in the British Army, and used this for locating gunfire.

I mean by that a distance away from the observer, that a gun was fired. That can be done by using several of these and using the ordinary method of triangulation, knowing when the sound arrived at two or more stations, the gun being at an unknown point. The patent states, and I am starting at line 11 on page 1:

"This invention relates to an improved thermic sound detecting device intended more particularly for determining the position or the origin of a sound produced by the discharge of a gun, although the

(Testimony of Samuel S. MacKeown.)

use of the improved sound detecting device is not limited to such determination or origin, the invention being applicable also to the detection and measurement of such sounds and also to sounds emanating from other origins than from a gun, and being generally useful also, for other purpose, such as the measurement of velocity and consequently of the quantity of gases or liquids flowing through tubes or pipes."

This device is not only sensitive to that kind of a sound, that is, a report from a gun, but it is relatively insensitive to ordinary noises. That is because the wire cannot cool off sufficiently between the pressure and rarefaction wave to record the higher frequencies present in most sounds. [400]

The Court: What does he invent: the sound detecting device; I mean a microphone?

A. He has invented primarily the combination of this microphone, using it with an accoustical tuning resonator for any purpose it wants to be applied.

The Court: The microphone existed before; is that right? a combination of the microphone——

A: I don't know whether the microphone was used in this form prior to this time or not. It may have been. I believe all the claims, without having studied the claims, are limited to the use of the microphone with an accoustical resonator or a sound box.

The Court: The tuned accoustical resonator is a sound box?

(Testimony of Samuel S. MacKeown.)

A. In this case where the sound box is tuned it is a special resonator, because of the construction of it. The sound box on a violin or on a piano is not tuned, because its function is to reproduce clearly all the sound from the violin. On line 55, at the bottom of column 1, page 1, the patent states:

"the sensitiveness of the sound detecting device is constant, and the same does not respond to ordinary noises nor is it affected by vibration, and it assumes its normal condition immediately after each vibration.

On the bottom of this page he states that this microphone can be connected to an Einthoven string galvanometer, which is an oscillograph, to make permanent records of sound waves. [401] That is in the paragraph starting at line 99.

Tucker, in this patent, not only describes this microphone, but describes it in combination with different tuning accoustic resonators. That is shown best in Fig. 2. The microphone is at the right of this box, at the throat, and it is mounted with the terminals *i j*, which are means of forming the necessary electrical connection to the battery supplying the microphone current, and, also to the transformer or amplifier which will amplify the changes in the current existing there. The box indicated by *b* is a box, the volume of which can be changed, because the one side can be slided over the other, accordion style.

(Testimony of Samuel S. MacKeown.)

The Court: Is that box what you call a tuned accoustical resonator?

A. That in combination with the throat. That is *h*.

The Court: Where it goes into the opening of that *l*, little *l*?

A. That is little *l*. If we take a box and have an opening in it, and have connected to that opening a throat, then that box is an accoustic resonator, a so-called Helmholtz resonator, because Helmholtz was the first one to see that this is a resonator. And the frequency to which it will respond depends on the volume of the box.

The Court: And the cross section? [402]

A. The length of the throat. You can, therefore, change the frequency to which this will respond either by changing the volume of the box or the length or cross section of the tube forming the throat.

The Court: Take the whole side out here?

A. You see, we change the length of the box——

The Court: If you change it you take the whole side out?

A. No. The throat is the small opening indicated by the letter *h*.

The Court: The opening into the box is *l* isn't it?

A. Yes; but if we do not have a throat we will not have a good accoustic resonator.

The Court: I see. That is really the tuning device, when the box is set.

(Testimony of Samuel S. MacKeown.)

A. You can tune it by changing the throat or by changing the volume of the box.

The Court: If your throat is of a set length the tuning is accomplished by changing the size of the box?

A. That is correct; and that is shown in Fig. 2, how you can tune it by sliding the box and changing its volume.

The Court: All right.

A. On page 2, starting at line 116, that is described:

"The box *b* on which the sound detecting device hereinbefore described is attached, may be formed of two parts which are mounted telescopically, as shown in Figs. 1 and 2, in [403] order to vary the capacity of the box and thereby obtain a resonant effect."

On page 3, starting at line 12:

"According to a further feature of the present invention, use is made of a plurality of sound detecting devices, and more particularly of thermic sound detecting devices, each of which is combined with an accoustic resonator of a particular pitch in such a manner that a series of combined sound detecting device and accoustic resonators are obtained, the pitch of which extends along the whole range of accoustic vibrations, or along a portion of such range, according to the object in view."

Such a system is shown in Fig. 25 on the last sheet of the drawings in which there are four of these accoustical resonators, marked M^1, M^2, M^3 and M^4. Each one is adjusted for a different

(Testimony of Samuel S. MacKeown.)

frequency, because their length is different; and the hot wire microphone at the throat of each one of these, connected to wires up to the terminals of the switch S^2 can be used to connect any one of these four to the amplifier, which is marked A and so described.

I think the only important part of that is having the microphone connected through an amplifier to a recorder. This shows, then, a hot wire microphone in this case in an accoustical resonator connected through the amplifier, which is A, to a recorder, so that you get an amplified record of the microphone actually recorded. [404]

The Court: Is that what was new about this?

A. That is one of the applications of the Tucker patent. I think what is actually new in the Tucker patent is the use of this hot wire microphone in combination with the resonating chamber.

Mr. Graham: Q. Doctor Mackeown, will you take the Wyatt and Lehr patent No. 2,047,974, which is Plaintiffs' Exhibit No. 18, and compare that with patents 2,156,519 and 2,209,944 in suit?

A. This patent discloses apparatus and methods for determining the surface level of a fluid by means of using a pressure impulse, and recording the time necessary for that pressure impulse to travel down the casing to the fluid surface and return. This patent points out the difference between the use of a pressure impulse and the use of sound wave methods. In the paragraph starting

(Testimony of Samuel S. MacKeown.)

at line 10 of the first column, page 1, it says that the sound method is old, and it operates more perfectly in theory than in practice and then, in the last sentence of the next paragraph, starting at line 38, it says:

"The present method and apparatus affords means for determining well depths without the use of a sand line, and saving considerable labor; and without the use of a 'sound method' which is more or less unreliable."

In the second column, starting at line 29, the patent says:

"Before proceeding to a detail description of this [405] invention, it should be stated that it employs the impulse wave principle, and the impulse wave is not generated by sound, but is generated by causing a sudden change in pressure at the well head. This change in pressure may be occasioned by a sudden liberation of a sufficient quantity of gas at the well mouth to cause a sudden substantial increase of pressure or a sudden decrease of static pressure within the well head, and it may be accomplished so that only a slight change in pressure at the local point results."

There are two methods of determining the time required for this impulse to travel down the well and back. The one shown in Fig. 1, is one in which there is a small outlet pipe from the casing marked 9, on Fig. 1, and the patent states that the observer can use a stop watch and record the interval of time between the opening of the valve 6,

(Testimony of Samuel S. MacKeown.)

the quick opening valve 6, which initiates the impulse, and the time that he feels a puff of air from the outlet. In Fig. 2 is shown another method, where the outlet marked 13, Fig. 2, is connected to a microphone marked 15, which goes up to an amplifier which is marked 18, and then to a recorder, so that a permanent record can be made of the impulse, as it enters the casing from the impulse chamber, and also as it returns from any obstructions in the well. This method is described on page 2, starting at line 10 in the second column, where it states: [406]

"If it is desired to have the result of the test indicated or recorded, this can be accomplished by providing a small pipe connection 13 (see figure 2) which is attached to the casing 14 instead of the outlet 9, and this connection may carry a microphone 15 which is electrically connected with an indicating or recording instrument 16. If desired, the third connection 17 between the microphone and the indicator 16 may include an amplifier 18 connected to conductors 19 and 20 of an electric power circuit.

"The recorder 16 may be provided with a pen arm 21 which would be controlled by an impulse in the circuit 17 and this pen arm would carry a pen or pencil 22 to run on the face of a recording drum 23 mounted to rotate on a horizontal axis in bearings 24."

(Testimony of Samuel S. MacKeown.)

That is similar to the type of recorder used in the Echo-Meter, with the exception that in the Echo-Meter recorder the pen remains stationary and the paper is moved underneath it.

In the method of this patent, after determining the time required for the wave to come back, Wyatt and Lehr provide a formula which is a well known formula for calculating the velocity of the impulse wave in the gas. That formula takes into account the nature of the gas, and is a correct formula, which has been known for a long time, and if you take a sample of gas and determine its density and other characteristics, then you can apply this formula and calculate the velocity. [407] The velocity would not be, of course, the velocity of sound in air unless the gas in the casing happens to be air, but this formula will give you the correct value for the velocity. The method of initiating the impulse in the Wyatt and Lehr patent Plaintiffs' Exhibit 18, and the method of initiating the impulse in 2,156,519 patent are identical. Both of them use an impulse chamber with a quick-opening valve.

In the Wyatt and Lehr patent a permanent record can be made with the apparatus shown in Fig. 2. That permanent record is made by using a microphone and amplifier and a pen recorder. That is a different method of recording than is used in the 2,156,519 patent, where a pressure diaphragm is used, and that pressure diaphragm actuates a small mirror, and the recording is done

(Testimony of Samuel S. MacKeown.)

photographically by light reflected from this small mirror actuated by a pressure diaphragm.

The time is measured in this Wyatt and Lehr patent and the distance is determined by using the calculated velocity of the gas in the well. If you know the time between the initiation of the impulse and the return of your velocity, then you can calculate the distance to the surface level. That is one of the methods used in patent 2,209,944 for determining the distance to the surface level.

The Court: What did Wyatt and Lehr invent?

A. They actually invented the impulse chamber as a source of pressure impusle. [408]

The Court: That is the only thing new about their patent?

A. Each one of the claims I think has as a limitation. You cannot infringe any of those claims unless you use that impulse chamber.

Mr. Graham: Dr. Mackeown, will you please take the Scott patent, No. 1,173,426, Defendant's Exhibit O-13, and consider the recorder system, the electrical system in that, with the recorder system in 2,156,519, the patent in suit?

A. This Scott patent describes an electrical system of amplifying and adjusting an amplifier so it is selective to certain frequency bands, and there is no such system in the 2,156,519 patent. It does not use any electrical means of recording or amplifying. This amplifier, with the filter circuit, is the type of circuit that is used in the defendant's apparatus.

(Testimony of Samuel S. MacKeown.)

The Court: To express the behavior of the Scott circuit in its simplest possible terms, as I understand it, the sound is first amplified, then it is reduced by taking certain sounds out of it, assuming it were sounds?

A. Yes. And where it is reduced, when you get a low voltage in that circuit, allows a maximum gain in your amplifier, to the things you want to amplify. There is no tuned or resonant circuit in this.

Mr. Graham: Q. Doctor, will you take the Halliburton patent, No. 2,201,311, Exhibit O-4, and discuss that patent [409] in connection with the patents, in suit, or the defendant's system?

A. This patent describes a method of locating the position of a plug in a casing, the plug being used for cementing purposes, and it is desirable to know how far down in the casing this plug has been forced, and this is done by mounting on the cementing plug two arms on springs, which, when they pass a casing joint, will move outward and hit the casing core and give a noice; that noise then travels up through the casing. The casing carries the noise sound very well. It is then recorded by a microphone at the top of the casing. The response goes through a filter and an amplifier, and gives a record of the number of casing collars that have been passed. Fig. 1 shows the cementing plug down the well, with the arms on it, just before the arms come to a casing collar. As they pass this casing collar they will spring outwardly and hit the casing collar,

(Testimony of Samuel S. MacKeown.)

and give a noise, which will travel upward through the casing to a microphone, which is shown in Fig. 5. This microphone is clamped against the casing and the sound is conveyed from the casing to the microphone by metallic contact. The microphone, which is shown schematically in Fig. 8, then goes to the filter, which is marked 41.

A. The microphone is shown by 22, and the microphone consists of a diaphragm, which is in contact with the metal [410] pipe, and this is an iron plate and as it moves back and forth, and changes its position relative to the core, which is 22, that changes the current in the winding 40, and that current then goes through the filter, which is 41, through the amplifier 42, to the recorder, which is a magnetic recorder; that is, it is operated by the magnet 43; and that magnet pulls upward on the armature 44, and causes the stylus 46 to move downwardly and make a record each time a casing collar is encountered. The record that is obtained is shown in Fig. 6. Each time a casing collar is encountered you get a mark, due to the sound which travels up through the casing, which is picked up by the microphone, goes through the filter and amplifier, and operates this recorder.

The description in this which we are interested in is on page 2, starting line 16 of the first column, and then on line 55 of the first column and line 67. The paragraph starting line 67 describes the use of the filter, and I might read a sentence or two of that.

(Testimony of Samuel S. MacKeown.)

"Now it is known that electrical impulses of comparatively low frequencies, such, for example, as the frequencies which correspond to audible sound, can be filtered to remove all impulses or other frequencies. If, therefore, a suitable filter is provided within the recording apparatus 25, as shown at 41, the recording instrument therein will receive [411] only the impulses caused by the knockers 16 and 17 striking the casing. It is preferable also to provide some electrical amplifying circuit within the recorder 25, and this is shown at 42 in Fig. 8."

Then it goes on to describe the recorder.

The Court: By a suitable filter he means a filter known to the prior art?

A. The filter design is something that has been known since 1916, and has been extensively worked on, and the design of that is well known, primarily from the telephone company; the Bell Telephone Laboratories have done the major work on that.

Mr. Graham: Q. Did you compare that detecting recording circuit in this Halliburton patent with the detecting recording circuit which is used in the defendant's devices in this suit?

A. Both of the recording circuits, that is, the one shown in the Halliburton patent, and that used in the defendant's apparatus, make use of a microphone for changing the sound impulses into electrical impulses, and, then, all of them include an amplifier, and the apparatus in the defendant's apparatus includes inside the amplifier a filter which may at times be used. The filter is used differ-

(Testimony of Samuel S. MacKeown.)

ently slightly than as shown in the Halliburton patent, and is used in the method shown in the Scott patent, but both of those use a microphone, a filter and an amplifier, and from that amplifier a recorder, which mechanically gives you the marks showing [412] in one case the casing collars and in the other case, the Echo-Meter, the tubing collars.

Q. Dr. Mackeown, with respect to the reissue patent in suit, I will call your attention to certain publications that have been offered in evidence, and ask you to compare those publications with the disclosures of the reissue patent. The first one is the article by Wilde and Moore: A Method for Determining Production Allowances in Prorated Fields, which is Defendant's Exhibit K-1.

A. This article by Wilde and Moore is on a method for prorating oil wells based on both the acreage and the capacity of the individual well to produce, and in this article Wilde and Moore show how you can obtain the capacity of the well, the productivity index, or the maximum production capacities, by taking bottom hole pressures at different rates of production and plotting them to obtain a curve, and from that curve determining either the productivity index or the maximum capacity in the well, which then can be taken in as a factor in prorating the different wells.

On page 72, starting in the second column, under the title "Bottom Hole Pressure Relationships" are several paragraphs which describe the condition at the bottom of a well, and where the production can

(Testimony of Samuel S. MacKeown.)

be obtained from this type of curve. The curve is shown in Fig. 1, and of the whole of this paper, I think the only part that is pertinent is that [413] portion under this heading "Bottom Hole Pressure Relationship" because that describes this method of determining the production of the well from measurements of the bottom hole pressures. This is the same type of curve as is shown in Figs. 4 and 5 of the reissue patent. In both of these curves you have plotted on your abscissa the production rates in barrels per day, and as the ordinate the bottom hole pressure, and in the curves, in the reissue patent the ordinate is marked pounds per square inch at the pump, but that I think is essentially the same thing.

That would be, if the pump was at the inlet to the well, the inlet from the sands. That is where you want your pressure to be zero to get your maximum capacity; not actually physically at the bottom of the well, nor at the location of the pump, but actually at the inlet from the oil sands to the well. When the pressure is reduced to zero, then you are getting the maximum amount of oil flowing into the well that is possible from the sand. I think there is no need of reading this portion of this article. It is a recognition of this method of using bottom hole pressures for determining the production of a well.

Q. That article is dated June 30, 1931. You referred to that chart on page 72 as being like this shown in the reissue patent, is that correct?

(Testimony of Samuel S. MacKeown.)

A. That is correct. This does not show a straight line. [414] It may be that in the well in which these curves were taken it is not a straight line relationship, but there are sufficient points there so that you can determine from that the place where the pressure will be reduced to zero at the bottom of the well and the maximum potential capacity of the well.

Q. Will you take the Hawthorn article entitled "Sub-surface Pressures in Oil Wells and their Field of Application", Defendant's Exhibit K-3, and compare that with the disclosures in the reissue patent in suit?

A. This is a rather long article, but I think we can limit our discussion to one particular case that Hawthorn talks about and as to which he shows the results in Fig. 1, which is on page 153. This article by Hawthorn is a general discussion of methods of obtaining subsurface pressures in oil wells, and their use, and he goes into a definition of the terms, and how the subsurface pressure can be calculated in certain cases. The particular case exemplified in Fig. 1 on page 153 is described on page 152, and I will read the first paragraph so we will understand what is plotted there, and what the meaning of these curves are, under the title "Subsurface Tests":

"Subsurface pressure tests in general may be divided into two classes, namely static tests and flowing tests. In either case pressure may be obtained

(Testimony of Samuel S. MacKeown.)

at any point within the [415] flow column to which a pressure bomb can be lowered, thus giving information from which curves or pressure gradients can be plotted; see Fig. 1, where curve 1 is the static pressure gradient, curve 2 is the flowing pressure gradient and curve 3 is obtained by plotting bottom-hole pressure against rate of production of the well during the test.

"This constitutes all the information in regard to pressure that is directly obtained in making a subsurface test. If desired, the bottom-hole temperature may be easily obtained by attaching a maximum indicating thermometer to the bomb."

Referring to Fig. 1 on page 153, we have three curves on that. Curve I is a plot between the pressure in pounds per square inch, plotted on the ordinate, and the well depth in feet plotted on the abscissa. That is the middle curve. That curve is a straight line from the bottom of the hole, which is at some 3700 feet to a point about 750 feet, and that straight line is the drop occurring in the fluid column. This is a static curve, which was taken when the well was shut in. From 750 feet approximately to the top of the well is the increase of pressure, the small increase in pressure, due to the gas column.

Q. And that is marked 1 on the curve?

A. That is marked 1 on the curve, and the gas column and the intersection of those two curves is marked as the [416] fluid level encountered at 725 feet. To the left of this curve is a calculation of the specific gravity or density of the pressure gra-

(Testimony of Samuel S. MacKeown.)

dient in that column. Under the heading "Calc lation of Specific Gravity" it reads, "Pressure dr 33.1 pounds per 100 feet. Therefore the speci gravity equals 31.1 divided by 43.43, equals .762 And then below that "Baume equals 53.75 degrees Baume is a density scale, or a scale of density us commonly in the oil industry.

We have here, then, a pressure drop or pressu gradient giving the specific gravity, which is t density of the oil in that column or the fluid in th column, referred to water as 1, that the fluid in th column has a density of 76/100ths of water. It lighter than water. And also the density given Baume.

Curve 2 is for the gradient or density when t well is flowing. The right-hand portion of th curve, referring to the column at the lower pa of the well, is a straight line and is parallel to t curve 1. That indicates that in that portion the well, the lower portion of the well, there is n gas and that the fluid column consists only of t liquid oil, and that portion of the curve is marke "Oil column".

At approximately 2700 feet on this curve there a point which is marked, "Breaking point in curv Gas starting out of solution," and from that poin to the top of the well that curve gradually change it isn't a straight line but [417] has a small amoun of curvature. That means that in that portion o the curve the density does not remain strictly con stant, but decreases as you go up in the well. Tha

(Testimony of Samuel S. MacKeown.)

is because the liquid in the column is moving from a point of high pressure at the bottom of the well to a point of low pressure found up in the column. The pressure in the fluid is constantly reduced and the gases, which were dissolved in the fluid in the oil at the higher pressures, now can come out of the liquid, and that gives a change in the pressure gradient or density of that oil in this flowing column.

The density at any point can be determined by taking what is spoken of as the slope of this curve; even though it is not a straight line it is easy to determine the density at any point. I should say that the curve 2 is taken for a flowing well; that is, a well which is not being pumped but in which the oil moves up to the surface by the pressure in the formation.

On page 159, at the bottom of that page, it reads: "Fig. 1 illustrates an actual test performed on an East Texas well. The static gradient indicates the well to be of the semi-artesian type, inasmuch as the pressure is insufficient to raise the column of oil to the top of the hole."

Evidently this is not a complete flowing well, and probably operating by gas lift. I was incorrect when I said it was a well which flowed simply from the pressure of the formation. [418]

"By projecting the static oil column gradient downwards, the point at which the curve crosses the horizontal axis would indicate the height in the tubing to which oil could be sustained by the exist-

(Testimony of Samuel S. MacKeown.)

ing formation pressure, if the gas on top of the oi column were released. As previously mentioned, th gravity of the oil may be calculated from the stati gradient."

The static gradient is that obtained from curv 1, and is that given in the calculation. It mean the pressure gradient under static conditions, an it is calculated there as the pressure drop per hun dred feet and is actually 33.1 pounds per hundre feet. That is the value of the pressure gradien under static conditions.

"If any appreciable amount of water happene to be present at the bottom of the hole it would b immediately reflected by showing a curve of eve greater slope than that for the oil column."

That is a condition that sometimes exists in an oi well where you have water separating out at th bottom of the well. In that case, under no condi tion is the density of your fluid constant through out the column, because you have two differen liquids, water at the bottom and oil at the top. Bu that is not shown in this curve.

Then reading on, the second paragraph on pag 160:

"The flowing gradient in this same figure is o interest in that through it several theories ar substantiated." [419]

The flowing gradient is the pressure gradient o the density obtained from curve 2 where the oi is flowing.

(Testimony of Samuel S. MacKeown.)

"It is seen that for a distance of nearly a thousand feet up from the bottom of the tubing the flowing gradient is a straight line and is parallel to the static gradient. The gradient then breaks off into a curve with a gradually decreasing slope."

That fact, that it has the gradually decreasing slope, means that the density of that column is gradually decreasing. Then continuing:

"The only logical way of interpreting this curve is that all gas is in solution in the formation and that it remains in solution for a considerable distance up the tubing. When a point in the curve is reached at which the pressure approximages 700 lbs., gas starts out of solution. As the pressure decreases upward in the tubing more and more gas is liberated from solution, thus causing a corresponding lightening effect of the column. Emphasis is placed on the fact that this chart represents no mere coincidence, for the conditions as shown in these curves are duplicated in almost every test performed in the field."

So this article shows how it is possible to obtain the density from a curve of pressure and depth by taking the slope of that curve, and that in a flowing column of oil in which no gas is being evolved, that the density is the same as in [420] the—let me correct that—this shows that where the fluid column is a liquid and there is no gas in it, the density is the same as you would obtain in the static condition; that as gas comes out of solution from the liquid, then there is a decrease in

(Testimony of Samuel S. MacKeown.)

the density of the fluid, that fluid being then a mixture of gas and liquid.

Q. You have said from that curve that you can do certain things. How is that curve plotted?

A. This is curve Fig. 1 on page 153. That is the only figure that we have referred to in this article. That curve is plotted in pressure in pounds per square inch against well depth in feet. I might say that curve 3 of Fig. 1 which is in the upper left hand corner, is a plot of production in barrels 14 per hour against the bottom hole pressures in which the productive index of the well can again be obtained. The values for the abscissa now are in the top of that curve, giving the production in barrels per hour.

Q. Now, will you take the article of Ihrig, or the article written by Ihrig in the Oil and Gas Journal; it is Defendant's Exhibit K-5; and compare that with the disclosure of the reissue patent in suit.

A. This is a one-page article which gives an account of the determination of the bottom hole pressure in an oil well under two rates of production, and shows how these bottom hole pressures can be used to determine the maximum production [421] from the well. This well produces both water and oil. The Fig. 1 is seemingly the actual record obtained from the pressure recorder which was in the well during these tests. The pressure recorder ran for some 39 or more hours, and gives a graphic plot of the pressure existing in the

(Testimony of Samuel S. MacKeown.)

fluid as time goes on. The left hand part of that curve shows a rapid increase in pressure, which is when the pressure recorder is lowered into the well; then the well is started pumping and the pressure decreases and becomes a constant value after approximately 15 hours. The pump has been on a constant production rate and it has taken that long for the equilibrium or stable conditions to obtain; and from that time onward as the rate is kept constant you obtain a bottom hole pressure, which is the bottom hole pressure under equilibrium or stable conditions. That gives a pressure, then, at that rate of about 190 pounds. Then the production rate was changed and another reading was obtained at approximately 30 hours after the start of the record for another rate of production. On Fig. 2 these results are plotted.

As I stated, the well makes both water and oil, and we have the two points on each of those curves giving the rate of production of oil at two different bottom hole pressures and the rate of production of water at two bottom hole pressures. The lower curve, which shows less production, is for the oil, and the higher curve is for the water.

I might remark that this Fig. 2 in this Defendant's [422] Exhibit K-5 is identically the same as Figs. 4 and 5 of the reissue patent 21,383 with the exception that it is turned around. In other words——

The Court: It is upside down?

A. Turned upside down.

(Testimony of Samuel S. MacKeown.)

Mr. Graham: Doctor, will you take the article by William Victor Vietti, Defendant's Exhibit K-9 and compare it with the disclosure of the reissue patent in suit?

A. This is an article entitled, "Density of Oil-Gas Columns from Well Data", and describes a method used by Vietti to determine the density of a column of fluid which contains oil and gas. The method he employs is shown in both Figures 1 and 2. What he does is plot the casing pressure against the production in barrels per hour, then he extrapolates this curve down to zero production, that is until it hits the abscissa line in the lower left hand corner. That value gives him the casing pressure that exists when there is a column of both gas and oil in the tubing even though the production is zero. That is obtained by extrapolating this curve downwardly. It is actually a different value than he would obtain if he closed down the well, because in that case the oil and gas would separate and you would have a liquid column and a gas column. But by taking these values at different rates and then extrapolating it down to zero flow he can obtain the casing pressure which would exist at zero flow if you had [423] the mixture of liquid and gas in your fluid column. Now, he knows the pressure in the formation or what he calls the shut-in pressure or rock pressure, and from those data, the rock pressure and the casing pressure and zero flow, he is able to calculate the density of this mixture of gas and oil. That is

(Testimony of Samuel S. MacKeown.)

explained in the next to the last paragraph on page 216, which states:

"The subtraction of the shut-in pressure thus found from the measured rock pressure of 700 pounds per square inch gives us the pressure exerted by the fluid column (X pressure). Some error is involved by the fact that flow starts somewhere back in the formation and not at measurable points such as the top of the pay or bottom of the hole. Dividing the weight of the fluid column by the distance to the point of entry to the well bore gives us the average weight per foot of the fluid column. The average density of the column can then be calculated. These were calculated on the distance to the top of the first flowing zone and the total depth of the wells."

The Court: "Dividing the weight of the fluid column by the distance to the point of entry to the well bore"— Where is that point of entry to the well bore?

A. Let us assume that the point of entry is where the perforations are. He was measuring from the top of the well to that point, and dividing the pressure of this column which he has obtained by subtracting the casinghead pressure from [424] the rock pressure by the height to obtain the pressure gradient or the density in the mixture of oil and gas existing in that column.

The Court: What is the difference between the weight of the fluid column and its density?

(Testimony of Samuel S. MacKeown.)

A. The weight of the fluid column per 100 feet is spoken of as pressure gradient, and is proportional to the density.

Mr. Graham: Q. What is the difference between density and weight?

A. The weight of material is actually what it weighs, but density is weight per cubic foot. If we speak of weight of the column of gas, the weight of 100 feet of that pressure exerted by 100 feet of that is spoken of as the pressure gradient, and it is proportional to the density of the fluid. It is not the same value, but it is proportional to it.

The Court: Q. He has used weight per foot and density simultaneously.

A. They are the same, except they are expressed in different units, and consequently have a different numerical value.

Q. The average per foot of the fluid column would be identical with the average density?

A. Not numerically, but they would be for all intents and purposes. In other words, the density is the weight per [425] cubic foot; in the case of water it is sixty two and a half pounds. The gradient of the column of water, the pressure gradient or the weight per foot is .43 pounds. They are different numerical values, but they are proportional, one to the other. You can easily convert one to the other, and I think for all intents in this case they are the same, because it is easy, if you know it, to obtain the other pressure gradient.

(Testimony of Samuel S. MacKeown.)

The Court: Is there any way of proving these things, or is this a mathematical calculation?

A. These are taken from several wells, and he has given in Table 2 tabulations, and I don't know how well accepted this is. Seemingly, Vietti seems to think that this is a reliable method of getting such information about the average pressure gradient or average density in a mixture of oil and gas, or I don't think he would have published it.

Q. Do you think it is?

A. Yes, I think it gives information, particularly in this field.

Q. Is it accurate?

A. I don't know how accurate it is. He has a great many points on this curve on top of Fig. 3, and it seems that they are scattered around that line, and he has drawn a line which I think we can take as an approximate value from these data. [426]

Mr. Graham: Q. I have one more, the Tucker article, Defendant's Exhibit K-4, which appears in the Journal of the Royal Society of Art, 1923. That refers, I believe, to the hot wire microphone. Will you just refer briefly to the pertinent parts of that, Doctor?

A. Yes, I can be very brief with this article, because this describes the microphone and the acoustical resonator which were described in his patent. I would like simply to refer to page 122, to the short paragraph in the second column. The first paragraph, starting in the second column, which states:

(Testimony of Samuel S. MacKeown.)

"Mere noise, however, does not produce an appreciable effect, as can be shown by sounding a klaxon horn in the immediate neighborhood of the microphone."

And I would like to read the next sentence in the first paragraph:

"The selective character of the microphone may further be illustrated by contacting it with the solid-back carbon microphone. In July of 1916, I was able to take parallel records of sound at Mount Kemmel with these two instruments. (Fig 2)".

And then at the bottom of the page is a curve that is printed Fig. 3, and then in my copy is crossed out to be Fig. 2, and it has the caption: "Records of Two Gun Sounds, with Hot Wire Microphone and with solid back Carbon Microphone".

[427]

There is a comparison of the response of the two microphones. The upper curve of that one strip (next to the lower strip on P. 122 of article) shows a record made by the hot wire microphone, and shows, with the exception of the two shots, one about one-third the way along the strip, and the other a little bit more than two thirds of the way, a record relatively straight, and it is not marked by disturbances. The lower one shows a record made with a carbon microphone, which does show the two shots, and it also shows a lot of other irregularities.

There is one other point in this I would like to take up, to clear one question that your Honor

(Testimony of Samuel S. MacKeown.)

had the other day. I will read just a sentence, starting in the last line on page 124 of the Tucker article, which states:

"One effect, however, must be particularly referred to, viz., that the microphone wire is indifferent to the direction of the disturbing blast, since in both cases the wire is cooled, the resistance is diminished, and the record shows a succession of peaks entirely on one side of the zero line."

And then in Fig. 12 he shows a record made of the current in the hot wire microphone, and in the upper curve, which is marked "Grid Vertical" you see that all of the changes are above the zero line which is shown at the left of that curve. Actually, each of the peaks of this curve represent not only a pressure pulse, but also a rarefaction. The valleys in that [428] curve represent the period between a pressure wave and a rarefaction, when no air is passing through the microphone. The reason why the curves made by defendant's apparatus do not look like this is because a transformer is incorporated in that apparatus, which takes away the slow changes of the base line, and you only see the variations. This curve is actually taken from the current in the microphone itself, and there is no transformer interposed between the microphone and the recorder.

The Court: In 12 (a) each one of these peaks is alternating, high and low, high and low. Is the high one the positive, and the low one the negative?

A. No, your Honor, the first high one, say, is

(Testimony of Samuel S. MacKeown.)

the positive; the second higher one the negative; the third higher one a positive, and the fourth higher one a negative.

Q. Why are these alternately smaller, and they all seem to hit about the same space, and it is completely regular, as to high and low?

A. If you will think of blowing through this microphone, you first blow through it and then suck. When you blow you put air through it. That gives a peak increase. The current then, when I stop blowing or sucking, the current decreases to its minimum. Then when I suck through it, I get another peak, so there are actually twice as many peaks on this as there are peaks of the pressure. Each one of those peaks [429] refers to the peak of the pressure, and also to the rarefaction. I think that answers the question you had the other day regarding why the defendant's curve did not show the characteristic action of this microphone.

Mr. Graham: I would like to straighten this out, Doctor, on page 122 at the bottom there are three records. There is some confusion about the numbers on these in my copy. Now, the one that you are testifying to is the second one from the top, isn't it?

A. That is correct. Unfortunately, I think in a misprint that was marked Fig. 3 in the printing; then somebody has changed that in pencil or pen to be Fig. 2. That is the one I am referring to.

Q. Doctor, there has been testimony here by Mr. Cornes about some tests that were made back in

(Testimony of Samuel S. MacKeown.)

Duncan, Oklahoma, with an apparatus built according to the disclosure of the Wyatt and Lehr patent. Were you there at the time of those tests?

A. Yes, I was. I participated in the making of those tests. I examined the apparatus that was used in the making of those tests. That apparatus was made in accordance with the Wyatt and Lehr disclosure of the pressure cylinder, and so forth.

Q. There are two photographs in evidence as Defendant's Exhibit H, and Defendant's Exhibit I. Will you please look [430] at those, and tell me if you can state what they are?

A. These are photographs of the apparatus set up in this well in Duncan, using the impulse chamber which is here in court, and as described in the Wyatt and Lehr patent as using, in the one case, that shown on Exhibit I, the carbon microphone, and that shown on Exhibit H, the hot wire microphone.

Q. Was the apparatus used, in so far as a means for introducing a pressure impulse into the well and the receipt of the echo from that impulse, the same as that disclosed in the Wyatt and Lehr patent?

A. Yes, and particularly that disclosed in Fig 2 of that patent.

Q. Doctor, the Wyatt and Lehr apparatus used there at Duncan, which you have just testified to, and which you have testified was operated by yourself and Mr. Cornes, did that apparatus record an echo from any tubing collar so that the distance

(Testimony of Samuel S. MacKeown.)

to the fluid surface could be determined by count tubing collar echoes. A. Yes, it did.

Cross Examination

By Mr. Mattingly: Q. When you say this paratus that was tested in Oklahoma was built accordance with the Lehr [431] and Wyatt pat did you build the apparatus?

A. No, I did not build the apparatus.

Q. Upon what do you base your statement t the apparatus which was assembled and tested th was built in accordance with the Wyatt and L patent?

A. Upon an examination of the apparatus, particular tests, and the running of the ampli and recorder.

Q. I understand that the apparatus which tested in Oklahoma included a pressure chamb a bottle of gas, from which bottle of gas a cert quantity of gas was let into this steel cylinder pr sure chamber, and was discharged from there b quick opening valve into the casing of the well that correct?

A. Not quite. There was a pressure line fr one of the shops, so we did not need to use bott gas; we could fill the impulse chamber direc from the line; but with that exception that is c rect.

Q. The pressure line from the shop was used a source of gas to put into that chamber?

A. That is correct.

(Testimony of Samuel S. MacKeown.)

Q. In connection with that apparatus which you just described, a microphone was used, is that correct? A. That is correct.

Q. Will you state what type of microphone was used? [432]

A. It was an ordinary carbon microphone, one which was in use, one I think which was used in the communication system of the Halliburton Oil Well Cementing Company; one of their spares that they had for their ordinary communication system inside the company.

Q. Was that type of microphone available in 1933?

A. Oh, yes; it has been available for 50 years.

Q. That was the type of microphone that was on the market at least as early as 1933?

A. Yes; an ordinary carbon microphone, common in the ordinary telephone transmitter.

Q. What type of recorder was used?

A. The recorder used was the recorder in the Echo-Meter apparatus. The recorder worked on the dynamic principle, the same in principle, and the same in general operation as the loud speaker diaphragms of practically every radio.

Q. Was a filter and amplifier used in connection with that recorder?

A. The test following the Wyatt and Lehr apparatus did not include the filter, but it did include the amplifier.

Q. Did the amplifier which was used in any way restrict or diminish the frequency response of the

(Testimony of Samuel S. MacKeown.)

recorder, the frequencies which would be com
back from the well which you were testing? [4

A. No. I did not personally make the test
the amplifier, but I saw a curve which Mr. Cor
made, which showed the amplifier itself gave a
sponse curve way out, very flat throughout the
quency range.

Q. Have you any idea when that type of
corder and amplifier assembly was first made; t
is, the one which you say is the Echo-Meter
plifier and recorder?

A. Do you mean the actual apparatus built t
was used, or when the type of amplifier and t
of recorder was first made?

Q. When was this particular one made; do
know?

A. I don't know. I think fairly recently.
was the one that is in court here. I believe t
is the actual recorder and amplifier that was u
at Duncan. Mr. Cornes so informed me.

The Court: You refer to one that is in cou
There was one that was demonstrated here. W
it that one or some other?

A. It was that one, and that one is still in cou

Mr. Mattingly: What I am referring to is
part of the apparatus which feeds the paper p
the pen. The pen and the mechanism upon wh
the paper is moved sidewise under the pen.

A. I don't know when that particular record
with all [43] of the details there contained, t
mechanical details and method of suspending t

(Testimony of Samuel S. MacKeown.)

paper, and so forth, was first designed. I know approximately when reproducers employing that principle were first used.

Q. You mean the loud speakers employed in radio reproduction?

A. Yes, and a little bit more than that. I mean with exactly the same type of magnetic circuit and electrical circuit, and so forth.

Q. Would you say that a pen and paper recorder of this type, which includes a stationary pen, the sidewise movement of the paper caused by an assembly you refer to as like a loud speaker, would you say that a particular recorder of that type was available on the market in 1933?

A. I don't know.

Q. Isn't it true that there was no such recorder available at the time? A. I don't know.

Q. The first time you ever saw one was when you started to work on this case; is that correct?

A. Well, the first time I saw one identically with this design and just this way, was in this box, yes.

Q. This recorder does have the characteristic that it has a very rapid speed response, does it not? [435]

A. I don't think it has a very rapid speed response. It has rapid enough speed response to get through everything that the microphone will pass, but it has not got a rapid speed response, compared to, well, let's say the ordinary loud speaker in a radio.

(Testimony of Samuel S. MacKeown.)

Q. It does not have the same speed resp as that?

A. No; because the mechanical system has n inertia and consequently, cannot respond to as h frequencies.

Q. Then this recorder would not respond to record sourd frequencies that would be super posed upon the echoes of the gunshot from the ing collars and the other obstructions in a w would it?

A. Yes, I believe it would. I believe it wo respond to certainly the lower frequencies th It will respond to everything that the microph will respond to.

I was thinking, Mr. Mattingly, if I may m a statement, when I spoke about microphones I thinking of the hot wire microphone particula that probably will not respond to all frequen passed by the carbon microphone. It will resp to the lower audio frequencies.

Q. Then I believe you have answered the qu tion that I was about to ask you, and that is whet or not these charts, Exhibits F and G, which supposed to be charts made with the so-called paratus that was constructed in accordance w the [436] Lehr and Wyatt patent, those charts not show those super-imposed sound frequencies the wiggles that represent the echoes from various things that were in the well?

A. They do show sound frequencies, the f

(Testimony of Samuel S. MacKeown.)

quencies which are in the lower part of the audible range.

Q. Will you point out what some of those frequencies are in these charts, and will you mark them as you find them?

A. There are frequencies present within this which, from peak to peak, are pretty close, and the tubing collars are, I believe, 30 feet apart. I think that was what Mr. Cornes testified. So that this being open to the air, the speed of sound would be some thousand feet or eleven hundred feet per second. So that we can determine the frequencies of the individual echoes from the tubing collars. Those are easily counted on this, and in between those are very much faster frequencies which would be up in the audible range; the frequencies are probably some place between 50 and 100 cycles. Those are indicated by what you might call the more rapid wiggles on the curves.

Q. Will you point out where some of those frequencies are, those wiggles you have referred to, and mark them?

A. I am referring to Defendant's Exhibit G. I can mark with a red pencil those that are discernible, Mr. Mattingly. Over in a range which I have indicated by a bracket, a number of peaks are pretty close together. They are not regular [437] peaks. They consequently include frequency waves relatively high.

The Court: That is, those short peaks. That is,

(Testimony of Samuel S. MacKeown.)

the bracket includes two long peaks and three short ones, is that right?

A. Yes. There are frequencies in there which certainly run to 100 or 200 cycles per second, and the only way you can determine what frequencies are recorded would be to apply Fourrier's analysis, and in that way find out what frequencies are present, but I know by looking at that, and having a rough idea of the frequencies between the main peaks that frequencies are possible that will run up several hundred cycles per second.

Q. Which peaks are tubing collars, the short ones or the tall ones? A. The tall ones.

Q. So in the bracketed portion which you have indicated in red, we will call X on this diagram, there is only one length of tubing?

A. There would be at least two lengths of tubing.

Q. There is one from here to here; from one high peak to the other high peak?

A. I think, your Honor, there would be another peak in here, which may be partly masked by these higher frequencies, because the rest of the curve shows that the space between the [438] two peaks you speak of is a space where you would expect another one.

Mr. Mattingly: Q. There should be one in that space, but it did not register as a distinguishable peak in this record, did it?

A. It is there, but these higher frequencies may have superimposed on that, and cut down that peak at that particular point. These higher frequencies

(Testimony of Samuel S. MacKeown.)

you ask about, which this microphone reproduced, which are recorded on the record, are superimposed on other frequencies, and sometimes you will miss one of the tubing collars, but you know it is there. It is like a picket fence. If you know a picket is out of a picket fence, it does not cause you any difficulty in knowing that a picket should be there; if you wanted to measure the distance by counting the number of pickets you would include that in your computation. They are regularly spaced, and you would know one is missing. I think Mr. Walker spoke about that on the upper part of the curve, where he said there were a number of disturbances but that did not cause any difficulty in counting the tubing collars, because you know how many should be in there.

The Court: The witness said "This microphone". Are you still talking about the carbon microphone?

Mr. Mattingly: Let us ask Doctor Mackeown: Are you still talking about the carbon microphone?

[439]

A. I am, because this defendant's Exhibit G was made with a carbon microphone.

The Court: What causes these sound frequencies that are superimposed on the tubing collar echo?

A. Those came from possible low frequencies present in the sound of a gun shot. This was not the sound of a gun shot—or from the opening of the chamber itself, or from some other disturbance.

(Testimony of Samuel S. MacKeown.)

I don't know just where they came from, but they are higher frequencies which are present.

Q. Those are all echoes? Every variation in that line represents an echo?

A. Yes; it must be an echo from something as soon as you get away from the starting point.

Q. There must be an obstruction?

A. Not necessarily, your Honor, because they may be echoes of higher frequencies; that is noise present due to the noise incident to the opening, or this pressure impulse being applied, which will register those as well as the echoes from the pressure impulse. Mr. Mattingly has been asking me whether this record shows and can register audio-frequencies; whether the recorder, amplifier and microphone used in this apparatus were capable of measuring audio-frequencies. I told him it was, because there is present in this record a record of audio-frequencies. Those are [440] things he is questioning me about now. These short frequencies have irregular waves in between the peaks due to the reflection of the pressure impulse from the tubing collar.

Mr. Mattingly: Q. I want you to mark on there what you think are tubing collar echo records.

A. Do you want to simply know those where I know there must be one but it is not obvious?

Q. You have testified from that record you can tell the number of tubing collars that are in that well. I want you to point out to the court how

(Testimony of Samuel S. MacKeown.)

it is you can tell the number of tubing collars that are represented on that chart.

A. I have put marks on these tubing collar echoes which are obviously tubing collar echoes. There are certain places—there are about three gaps in there where I haven't put marks, where it is perfectly obvious that tubing collar reflections should be in between, because the space between the adjacent marks is approximately double what it is between the others. If you were interpreting this you would have no difficulty in knowing that there were tubing collar reflections present which were masked or hidden.

Q. In other words, knowing that you want to look for tubing collar echoes you would be able to guess those peaks which you have marked represent tubing collar echoes?

A. If I had no idea there were tubing collars there, [441] nevertheless, I could take that record and from the regularity between echoes it would certainly give me a clue that there was something giving me a regular echo, and it would be easy to determine the length between marks on the record, and from that the spacing between the objects which will give me reflections, and that would certainly give me a clue to the fact that it was tubing collars, because the distance I would calculate from this record would be the distance between tubing collars.

Q. These intermediate loops or wiggles that you have referred to as being these superimposed fre-

(Testimony of Samuel S. MacKeown.)

quencies here, that's the same sort of thing that M
Walker has referred to as hash; that is, it is the r
cordation of such wiggles on the line which tends
knock out any wiggle that would be recorded, a
therefore it has hashed up that part of the record,
that a good statement?

A. Well, it has kept the record from being
easily recognizable, as if they were not presen
that is true.

Q. That was with the carbon microphone th
Exhibit G was made? A. That is true.

Q. My notes show that Mr. Cornes testified th
Exhibit F was made with a hot wire microphon
and Exhibit G was made with a carbon microphon
Exhibit F, I believe it was testi- [442] fied, w
made with the hot wire microphone; is that correc

A. That is correct. That is the difference b
tween Exhibits F and G.

Q. Will you take Exhibit F and mark on th
exhibit what you consider are the tubing coll
echoes, in the same manner you marked Exhibit G

A. It is easier to mark them on Exhibit F th
it is on Exhibit G, because the hot wire microphon
does not pass the higher frequencies and, cons
quently, those higher frequencies are not recorde
I have done that on the lower part of this recor
Mr. Mattingly. I have not done it on the oth
part, as the clerk has put his stamp on that par

Q. I would suggest that you mark the enti
length of that record strip to show all the collar
so that we can see how many there were.

(Testimony of Samuel S. MacKeown.)

The Court: These were made in the same well, as I remember the testimony.

A. They were, your Honor. I was there.

Mr. Mattingly: I offer the photostatic copy of Exhibit F, that the witness is now marking, as Plaintiff's Exhibit——

The Court: F-1.

Mr. Mattingly: I would like to offer that as Defendant's Exhibit F-1.

The Court: Yes. F-1.

[Printer's Note: Defendant's Exhibit F-1 is set out in full in the Book of Exhibits.] [443]

A. I have marked with red pencil on this exhibit a number of tubing collar reflections that are plainly discernible. There are several places, particularly up near the first part of the record, where it is not easy to pick out those tubing collars. I had previously on this record, when I had it in my possession, counted out ten of those tubing collars, and I know the distance that ten of them occur. Consequently, I know the distance that there should be between the spacing of any two tubing collars. So that I can very readily tell, if there is a gap, whether there should be one or two or three, or how many tubing collars in that area.

Q. Will you mark on this record, Exhibit F, the initiation of the pressure impulse and, also, the recordation of the echo from the fluid surface? Mark the initiation of the shot as "A".

A. I have done that.

(Testimony of Samuel S. MacKeown.)

Q. And the echo from the fluid surface as "B".

A. I have done that.

The Court: Which on the original exhibit is marked "Valve opened" and "Fluid level echo". The initiation of this shot is "A", and the fluid level is "B". How many tubing collars are recorded on that strip, Exhibit F, between the opening of the valve and the recordation of the fluid surface echo? [444]

A. What do you mean, "are recorded"? Do you mean that have definite positive indications that they are there, or how many actually exist between those?

The Court: Well, I guess he wants you to count the number of marks on there. Isn't that what you want? You have asked him to indicate where the tubing collar echoes are.

Mr. Mattingly: He has marked the strip here with a number of tubing collars and echoes, and then he says there are a number missing from the record. And I want to know how he can count the number of tubing collar joints from that record.

A. I have counted here, Mr. Mattingly, and I have clearly marked 14 tubing collars. If you think of this as a picket fence, for instance, you will notice that over a large portion of this you have a perfectly regular occurrence, and you can measure the distance between those. I have done that actually from that record, and you can see the calculations I have made there. Consequently, it is perfectly easy to know where tubing collars must

(Testimony of Samuel S. MacKeown.)

exist, even though they are not recorded, because you supply those just as you would supply pickets in a picket fence; if you want to measure it you would know where they should go.

Q. In other words, you add to the record that you have, such as Exhibit F, the additional information that there must be some more tubing collars in the well, and then you merely [445] measure off what you think is the space that should be occupied by those and fill those in mentally; is that right?

A. Well, you use your head in interpreting that. Yes; that is approximately correct.

Q. Then with this apparatus that was tested in Oklahoma, you selected there a recorder which, as far as you know, was not available on the market in 1933, and for making Exhibit F you selected the same microphone which the defendant is using now, a hot wire microphone. Will you please state whether or not that hot wire microphone was an article of commerce and available on the market in 1933?

A. It was certainly easy enough to build one. I don't know whether any concern had gone into manufacturing them and advertising them; but exactly how to build them had been described in a number of articles written by Tucker and Parris; a lot more than have been talked about in this case. There is nothing new about the recorder, except that I don't know that this particular design, in all details, was available in 1933.

(Testimony of Samuel S. MacKeown.)

Q. Can you account for the fact that on the record strip, Exhibit G, there was not recorded a great many more additional peaks or hash, such as is shown on Plaintiff's Exhibit 20?

A. Well, I don't know what the arrangement was in making [446] Exhibit 20. In know, in glancing at one of these exhibits, there was an awful lot of hash prior to what I thought was the initiation of the impulse, which would seem to indicate that there must have been a lot of vibration or other noise existing even before you put any noise down in the well. On one of these records I got the indication that that was the case, but I don't know what the arrangement is on this exhibit.

Q. Then you don't know whether or not the construction of the recorder which was used in these tests in Oklahoma, was such as to tend to damp out or prevent the recordation of these additional noises that would appear in the well, do you?

A. Well, I am pretty sure that it was fairly well damped, as you would want it to be. If it wasn't its own frequency, its own oscillation is going to introduce a lot of spurious effects, which may have been the case with the oscillator that was used in making these other exhibits that you have asked about.

Q. You have testified that the apparatus which was tested in Oklahoma was built in accordance with the Lehr and Wyatt patent. Will you explain to the Court what you mean by "in accordance with"?

(Testimony of Samuel S. MacKeown.)

A. Are you speaking now only of the recorder or of the whole system starting from the microphone?

Q. I want you to explain what you mean by "in accordance with the Lehr and Wyatt patent"? [447]

A. All right. The Wyatt and Lehr patent shows, in Figure 2, as far as the recording system goes, a microphone. There are no specific instructions given regarding the microphone. That microphone is shown as 15 in Fig. 2. So that we used a microphone; we used the most common type of microphone; that is, the carbon microphone. And we used a microphone, also, which was known long prior to Wyatt and Lehr's patent, which also had been shown to be particularly useful in recording gun shots. We used two different things. Then, 18 is shown to be an amplifier with no details, at all, regarding the amplifier. And we used an amplifier that was available that had a response throughout certainly the major portion of the audio frequencies. 16 is a recorder, and that recorder is described on page 2, column 2, starting at line 21:

"The recorder 16 illustrated may be provided with a pen arm 21 which would be controlled by an impulse in the circuit 17, and this pen arm would carry a pen or pencil 22 to run on the face of a recording drum 23 mounted to rotate on its horizontal axis and bearings 24."

Wyatt and Lehr here give, as an illustration, a type of recorder which can be used where a pen or pencil moves across a moving strip of paper to

(Testimony of Samuel S. MacKeown.)

give an ink trace of your motion. We had available a mechanism in which the paper was moved, rather than the pen. There is no difference, parti- [448] cularly, in doing one or the other. This was available and certainly, I believe, it is a perfectly fair representation of the recorder arms in the Wyatt and Lehr patent. Whether the paper moves relative to the pen or the pen moves relative to the paper, it is the same thing.

Q. But you did not, in assembling that apparatus, attempt to find a recorder which was available or on the market in 1933 at the time the Lehr and Wyatt application was filed, did you?

A. No. There were such recorders and we could have done that, but it did not seem necessary.

Q. Did you ever see any apparatus constructed by either Mr. Wyatt or Mr. Lehr, or both of them, in accordance with the Wyatt and Lehr patent to which you have testified?

A. No, I never saw any apparatus constructed by either Mr. Wyatt or Mr. Lehr.

Q. I want to refer to the article by Tucker, about which you testified, Defendant's Exhibit K-4. In Figures 12A and 12B on page 126 of that article, the type of record there is a record of a continuous sound, is it not?

A. A continuous sound, yes.

Q. As distinguished from a pressure impulse or a gun shot? A. Yes.

Q. In neither the defendant's apparatus and

(Testimony of Samuel S. MacKeown.)

system, nor [449] in the plaintiffs' apparatus and system, is there a mere noise used, is there?

A. No, in neither one; just a sound without a pressure impulse accompanying it. That's true.

Q. Both the defendant and plaintiffs use a pressure impulse which may or may not be accompanied by sound? A. That is correct.

Q. I believe in the demonstration we made in court both were accompanied by sound.

A. They were.

Mr. Graham: We offer in evidence file wrapper of application 171,170, as Defendant's Exhibit Q. And that became abandoned, your Honor. That is a certified copy of the file wrapper.

[Printer's Note: Defendant's Exhibit Q is set out in full in the Book of Exhibits.]

The Court: When was that abandoned?

Mr. Babcock: April 20, 1939.

Mr. Graham: That was a written abandonment filed by the inventor, I believe, as appears in the file wrapper.

I offer in evidence a certified copy of the file wrapper of patent No. 2,161,733, as defendant's Exhibit R.

[Printer's Note: Defendant's Exhibit R is set out in full in the Book of Exhibits.]

The Court: The application is Serial 268,805?

Mr. Graham: That is correct. I offer in evidence a certified copy of the reissue patent in suit;

(Testimony of Samuel S. MacKeown.)

the file wrapper, which as your Honor has noted, had a serial number of 307,551.

The Court: That is "S" in evidence.

[Printer's Note: Defendant's Exhibit S is set out in full in the Book of Exhibits.] [450]

Mr. Mattingly: Referring to all three of these file histories that are now in evidence as Defendant's Exhibits Q, R and S. Would your answer be that you had read all three of those file histories?

A. There was a great deal which I did not read, but I glanced through all of them.

Q. You did not notice whether or not this Vietti article, Exhibit K-9, was cited by the Patent Office as a reference during the prosecution of that application through the Patent Office?

A. I don't recall that I did.

Q. In the article by Vietti he is referring to conditions existing in flowing wells, is he not, as distinguished from conditions which might exist in wells which are being pumped by a mechanical pump?

A. Well, he is speaking primarily, as the heading shows, of the density of mixed columns of oil and gas. His data comes from flowing wells; that is true.

Q. And he describes in this article the determination of what he calls the "average density". Is that correct? A. Yes, he does.

Q. That is, the average density of the column of mixed gas and oil which is extended up into the well? A. That is correct. [451]

(Testimony of Samuel S. MacKeown.)

Q. Is that column of mixed oil and gas moving up through the well or is it stationary, static?

A. That is a rather interesting question. He obtains this from taking measurements when the column is moving, and extrapolates it down to when there is no movement. Now, this can, I think, most correctly be said to be a limit which is approached as the movement is decreased and approaches zero.

Q. By "average density" there, he is indicating that the actual density at any given time in that column of mixed gas and oil, that he is referring to, is actually a curve, and he is merely trying to determine what the average density would be, rather than to determine that the density is constant throughout the height of the column; is that correct?

A. I don't think there is anything in here which indicates that he thinks it is a curve. I didn't notice any place. He does speak about the average density of the column, but whether or not it is constant or variable I don't think he states.

Q. Well, he doesn't state in his article anything which would indicate that he understood or realized that the density was constant throughout the height of that column? A. No, that is true.

Q. The graph which is shown on page 217 of the article K-9, referred to as Figure 3, "Weight of Fluid Columns of Varying Gas-Oil Ratios", the greater portion of the line which is marked on that chart appears to be a straight line. That is [452] correct, isn't it? A. That is correct.

Q. Now, this line is the result of measurements

(Testimony of Samuel S. MacKeown.)

which were taken from a number of wells, rather than a line which is produced by measurements taken only in one well; is that correct?

A. The data contained in that curve are from more than one well. There is more than one point from some wells, but that curve definitely does include information from more than one well.

Q. And that straight-line portion of that curve is in no sense a representation or recognition of the fact that the density in the gas and oil mixture in the column in the annular space between the pump and the casing has a constant value?

A. No. It is on an entirely different subject, actually.

Q. I would like to ask you at this time if you will state if you know how it was that Mr. Vietti arrived at what was the rock pressure in the wells that he was measuring.

A. The rock pressure is obtained by closing down the well and having, then, under static conditions a column of oil and a column of gas in the well. You can determine the bottom-hole pressure, which would be the rock pressure, adding to it the pressure due to your gas column and your pressure [453] due to your oil column underneath it. And that is the way that the rock pressure or formation pressure was determined, as I understand the article.

The Court: How do you know the height of the oil column?

(Testimony of Samuel S. MacKeown.)

A. That can be measured by any one simple measurement of the fluid level——

The Court: In a flowing well?

A. That well is not flowing at this moment. It is shut down, under static conditions.

The Court: What I mean to say, no pump in the well?

A. No pump in the well.

Mr. Mattingly: Q. I call your attention to the first line on page 216 of the Vietti article which states:

"The bottom-hole pressure has been determined to be 700 lb. per sq. in gauge." Doesn't that lead you to believe that he obtained that rock pressure, you have been referring to, by a gauge?

A. I don't think so necessarily, Mr. Mattingly. There is another sentence, down about midway of the second paragraph that would rather indicate that he obtained it by taking the fluid column after he had separated it into two parts of oil and gas. This article itself is not explicit in stating just how he did obtain the bottom hole pressure. It is not explicit in stating whether it was obtained by means of a pressure [454] recorder or by making a determination of the fluid level and taking into account the casinghead pressure, the gas column and the liquid column. It is not explicit which method he used to obtain his rock pressure.

Q. Rock pressure and bottom hole pressure, as they are used by the Vietti article, are synonymous, are they not?

(Testimony of Samuel S. MacKeown.)

A. Yes, they would be, I think. That was actually where he obtained his bottom hole pressure, under no-flow conditions, which would be the rock pressure.

Q. Mr. Vietti in this article does not mention any way of getting this bottom hole pressure and rock pressure by adding the gas column and fluid column to the effect of the weight of the gas column?

A. The article doesn't state which method he used.

Q. He could have been using a pressure recorder in the well; in fact, the first sentence on page 216, where he mentions a gauge, would indicate to you that in all probability he made his measurements with a gauge, would it not?

A. I will say yes to the first part of the question, but not yes to the last part. That is, it does not state that it was made by measuring fluid level, but that first sentence does not give me a great deal of assurance that it was made by a gauge. We often speak of pressure by gauge so many pounds per square inch on the gauge, without necessarily implying that it was measured by a gauge. [455]

Q. Then, all that the Vietti article describes that is of any value in this trial, is that at the time of the Vietti article he knew that there was a relationship between the bottom hole pressure and production rate?

A. No, not at all. I would like to give you one or two sentences of what I think the important part of this is. That is, that Vietti at this time

(Testimony of Samuel S. MacKeown.)

knew that when you had a lower density than the density of the oil alone, that you could obtain the value of the density by dividing the height of the column by the pressure exerted by that column.

Q. And that would give you the average pressure throughout the height of the column, but not necessarily a constant density value throughout the height of the column.

A. Yes, that would give you the average value.

Q. But not necessarily that the value was constant throughout the height of the column?

A. No, it might not be constant.

The Court: Was there some novelty in the idea that you could determine pressure in the bottom of the hole by having the weight of the substance, or the pressure of it?

A. No, there was no novelty, and for that reason Vietti never described in this paper how he did determine that bottom hole pressure.

Mr. Mattingly: Q. Where you say Vietti never described it, you mean his article is silent as to this method of obtaining [456] bottom hole pressure by adding the gas column and then adding the weight of the liquid column?

A. That is correct.

The Court: What did you state this was that you said the important part of the article was——

A. Can I say again what I said——

Q. Say it again, so that I can write it down.

A. That Vietti showed that the density of the fluid column made up of a mixture of liquid and

(Testimony of Samuel S. MacKeown.)

gas was not constant, but depended on the amount of gas in the liquid. That's the first thing. And that the average density of that heterogeneous fluid could be determined by taking the height of that fluid and the pressure exerted by the column.

Q. Yes. A. That's all.

Mr. Mattingly: Q. When Vietti expressed it this way, that if you know the bottom hole pressure, and you know the entire height of the well, and this mixture fills the entire well, you can get your average density by dividing the height of that column by the bottom hole pressure?

A. He goes a little further than that and says if he knows the rock pressure or bottom hole pressure at no-flow, which is a constant, does not change, that he can do it. He does not have to know the bottom hole pressure except for the no-flow. [457]

The Court: There is a third element; if he knows the bottom hole pressure, the depth of the fluid, and the casinghead pressure? A. That is correct.

Mr. Mattingly: Q. I refer you to the Hawthorn article. Did you, in your review of the file history, Defendant's Exhibits Q, R and S, note that this Hawthorn article was also cited by the patent office as a reference in each of those applications?

A. No, I did not, Mr. Mattingly. I did not make special notes on what articles were cited of the prior art. I may have known at the time, but I certainly don't recall now whether it was or not.

Q. The reference to wells that is made in the Hawthorn article is made to flowing wells rather

(Testimony of Samuel S. MacKeown.)

than wells that are being operated by a mechanical pump, isn't that true?

A. No, not flowing wells. For instance, the well we were talking about, which is shown in Fig. 1, page 153, is not a flowing well, but a well in which, when it is shut up, the liquid rises to a height of about 750 feet from the top. It cannot flow. That is definitely spoken of on page 159.

Q. Is that well, so far as you know, being operated by a pump?

A. I don't know whether it is being operated by a pump. [458] It might be being operated by a pump, or it might be operated by a gas lift. I don't know, but it must be one or the other.

Q. You referred to two curves on page 153 of that Hawthorn article. Do you know how the various pressures that are plotted on that graph, Fig. 1, were obtained?

A. Yes, Hawthorn obtained those pressures by using a pressure recorder.

Q. I refer you to Wilde and Moore's article, that is, Defendant's Exhibit K-1. Do you know how the pressures, or the bottom hole pressures referred to in that article were obtained?

A. No, I do not. I don't recall that Wilde and Moore describe the method they used for obtaining the bottom hole pressure.

Q. In any of the articles, or in the prior art patents that you have referred to in this case do you find any of them which gives a description of finding bottom hole pressure by first finding the

(Testimony of Samuel S. MacKeown.)

fluid level, and then adding the effect of the column of gas to the gas pressure at the casinghead, and then adding the effect of the weight of that liquid column below the gas? A. Yes.

Q. Where?

A. In the Gill article, which is Defendant's Exhibit K-2, in the second page of that photostat, which is page 28 of the [459] article, under the heading "D", this article tells of doing just that. Do you want me to read it?

Q. I wish you would read that portion of it which states what I have just asked you.

A. "In fields where the bottom-hole pressure is sufficient to support a solid fluid column to the surface, it has been found possible to calculate shut-in bottom-hole pressures with a considerable degree of precision from the surface pressure and the average specific gravity of the fluid column. A similar calculation can be applied in fields of lower pressure, provided the height of the standing fluid column can be accurately determined. This method is particularly applicable in East Texas, and affords a simple and rapid means of following changes in bottom-hole pressures."

In other words, in the second case he says that by knowing the fluid level you can determine the bottom hole pressure by taking into account the weight of the fluid and adding that to the weight exerted on the surface of the fluid.

Q. Would you mind going on with that quotation, to the next sentence?

(Testimony of Samuel S. MacKeown.)

A. "However, the calculation cannot be made until the average specific gravity of the fluid column has been accurately determined by actual measurement of bottom hole pressure."

Q. What do you think he means by "actual measurement of [460] bottom hole pressure"?

A. That some time during the operation of this field it is necessary to determine the bottom hole pressure probably by means of a gauge, and having once done that, and determined what was the density of that fluid column, then you can apply the other method.

Q. Is the fluid column he is talking about a column of dense fluid, or is it a column of mixed oil and gas such as we have been talking about in pumping wells, and described in the patents in suit?

A. It is a column where the oil and gas are separated.

Q. It is a dense liquid?

A. Yes. He can make a close approximation of the density of the liquid, by taking a column of oil with no gas in it, but since he seems to want to be very accurate in his determination of it, and the effect of the density, he takes a liquid column with no gas.

Q. Neither that article or the Vietti article does describe or teach how, without knowing the density of the liquid column, you can determine the bottom hole pressure by finding the fluid level and pressure at that fluid level, then changing the fluid level

(Testimony of Samuel S. MacKeown.)

and finding another fluid level and another pre sure at that fluid level, and thereby determinin your bottom hole pressure? [461]

A. No, I think that is correct.

Q. I refer you to the Halliburton patent, D fendant's Exhibit O-14, patent No. 2,201,311. believe you stated that the recorder which is i lustrated in the Halliburton patent, Exhibit O-1 was the same as used in the defendant's apparatu here, is that correct? A. In general, yes.

Q. Is this the same construction that is illu trated in the Halliburton patent as is that in th defendant's machine?

A. No, I simply meant by that it has all o the elements that are in the defendant's apparatu I did not mean each one of the elements had th same mechanical structure.

Q. What type of filter is illustrated in the Halli burton patent, Exhibit O-14?

A. The filter is indicated in Fig. 8 by a bo just a block diagram, and there is no definite in formation regarding the type of filter.

Q. That might be a filter which would operat upon the resonance principle, could it be?

A. I do not call in general anything that op erates on the resonance principle a filter. I think that is not good nomenclature. I think filters ar entirely different from resonance circuits. Mos of the text books so recognize it.

Q. How could a resonance circuit be used a

(Testimony of Samuel S. MacKeown.)

a filter to permit the passage through that filter circuit of certain [462] selected frequencies?

A. Practically it couldn't be in this case.

Q. Why?

A. Beause the filter for these frequencies, if you want to call it a filter, built as a resonance circuit would be so heavy, so clumsy, would have so much resistance, that it would be absurd to build it. It would be extremely expensive, and would not work well, and it would weigh many hundred pounds. A tuned electrical circuit for low frequencies is never built practically, because it is so heavy, so ineffective, because of the resistance that necessarily comes in in its construction that nobody uses it. A filter for the frequencies needed to count tubing collars, if it were built of a resonant electrical circuit, would weigh much more than the total weight of the recorder that is used in the Echo-Meter.

We could have an electrical circuit which is tuned, and resonant. You have that in your radio receiver. Those are the circuits you adjust to pick up whatever station you wish. For very high frequencies those work beautifully, they are very light, and don't have much resistance in them, and they tune very sharply. If you build up a circuit for various low frequencies, then the amount of what we call inductance or capacitance that has to be used becomes extremely large, and they don't work effectively, because the inductance, with such a large amount [463] of wire in it, and resistance in

(Testimony of Samuel S. MacKeown.)

it keeps it from being highly selective. It woul have very slight selectivity. It isn't sharp. Bu there are resonant electric circuits which a especially something like your accoustical tune resonator acts, but they are entirely different fro the electric filter. In other words, you have tune electrical resonant circuits.

Mr. Mattingly: Before we leave the Hallibu ton patent, there is one point I would like to hav cleared up; that is, you were speaking of the fr quencies that would be dealt with in the Hallibu ton patent. That frequency is extremely low i the Halliburton patent as compared with the fr quency of the occurrence of tubing collar echoes i the echo methods which are discussed here, is tha true?

A. Yes. The frequency that we have for thes individual knocks would be lower than the frequen cy you would have in either the Echo-Meter or th Depthograph.

Q. The reason for that is that as the plug i being pumped down into the well by this slug o cement behind it, or whatever is pumping it dow there, the passage of that through a joint of pip is relatively slow as compared with the rapidity wit which tubing collar echoes would be received at th ground surface in defendant's and plaintiffs' ap paratuses, is that right?

A. That is right, Mr. Mattingly.

Q. And the transmission of the sound whic is produced by [464] this plug passing the indi

(Testimony of Samuel S. MacKeown.)

vidual joints is through the steel of the drill string rather than through the gas which is the medium of transmission we are discussing here in the Echo-Meter and the Depthograph apparatus, is that right?

A. That's right.

Q. Take the Fessenden patent, Exhibit O-4. What would be the speed of sound from the sounding device 49 to the receiving device 14 shown in Fig. 1?

A. The velocity would be a whole lot higher than that in air. It would depend on the type of soil. It might be five or ten times greater than that in air.

Q. What would be the speed of sound from the sounding d vice 49 to the point marked 46 on the rock or ore depth 44?

A. If the material through which the sound travels was the same material as in another path, the velocity would be the same. The velocity of sound depends only on the mechanical properties of the medium transmitting it.

Q. Then the soil between the sounding device 49 and the receiving device 14 might all be soft sandy soil, and that would have one speed of transmission, or one velocity for the sound, would it not?

A. That would have a velocity for the sound.

Q. And the soil or ground through which the sound will travel from the sounding device 49 to the deposit 44 might be [465] of a different nature and harder nature, granite for example, or a mixture between one path might be granite, and the other

(Testimony of Samuel S. MacKeown.)

part might be soft soil, so that the velocity along the line extending from 49 to 46 might be totally different from the velocity along the line 49, is that correct.

A. It is possible it would be different. When you say totally different, I don't know what you refer to, but it is possible, if you would have a different type of soil in one path than in the other, there might be some difference in the velocity of the transmission of those two paths.

Q. Is there any way that a person using the Fessenden device would know the type of soil along each of those paths? A. Yes.

Q. How?

A. By the fact that he has one transmitter and four different receiving devices, each one of which is capable of giving him the velocity of the sound through the medium between the transmitter and those respective stations. So he would know very quickly, on his calibrating run, whether or not it was a homogeneous medium throughout the whole area, and if it wasn't a homogeneous medium, which paths give the greater velocity.

Q. If he only used the receiving station No. 14 and the sending station No. 49, if he only used those two he would not be able to accurately plot the distance or position of the ore deposit 14, would he?

[466]

A. He could if it were a homogeneous medium and the velocities were the same throughout. If it so happened that the velocity differed radically in

(Testimony of Samuel S. MacKeown.)

ifferent directions and he only had that one sta-
on, then he could not.

Q. In an oil well, on any single firing of a shot
nd making a record, doesn't the sound have to
o through the same gaseous medium in order to
et down to the known obstruction and back to the
round surface as it does when it goes to the ob-
truction at an unknown location?

A. I think the answer is no to that. In going
o the lower level, which we might call the unknown
bstruction, it goes through a path of gas which is
enser than any other part of the path, and there
s no part of the path going down to the known ob-
truction, which is higher, where the gas is as dense
as the part of the path going to the unknown ob-
struction, or where the temperature probably is the
same. This is true, I think: that the constitution of
the gas, what it is made up of, is the same; but
your temperature can very radically affect your ve-
locity, and your pressure can, to some extent.

Q. But for practical purposes, as described in
the patents in suit here, you could assume that the
velocity from the top of the well to the bottom of
the well and back, that is, the average velocity,
would be substantially the same to the unknown ob-
struction as to the known obstruction; isn't that
correct?

A. That will make, probably, some error, but it
may not be very large. It would be larger in the
case where you fire [467] a shell, I think, than in
the other case, because then you have in the upper

(Testimony of Samuel S. MacKeown.)

part of your column a region which may be hot, due to the effect of the shell.

Q. Doesn't the flame arrester, which is used in connection with defendant's gun, cool those gases down to a point where the temperature of the upper end of the hole would not be raised appreciably?

A. I don't believe so. All it does is arrest the flame. Certainly the gas coming out of there I would expect would be very much hotter than the gas ordinarily in the top of the well. And I think you will find that if you take the top part of these records, that your tubing collar distances, where you get good tubing collar distances, may give you a different value than if you go further down in the well.

Q. You referred to the Batcheller patent, Defendant's Exhibit O-2, and you stated that the Batcheller patent disclosed the same type of mechanical recorder that was shown in patent 2,156,519. Will you explain what you mean by "same type"?

A. Well, I think what I meant to say there was that Batcheller used a rather large diaphragm and has an all mechanical system, nothing electrical in it; which is the type of recorder shown in the 2,156,519 patent. I did not mean to say that the structure of the diaphragm and the individual elements are the same, but simply that they work on a mechanical principle with a lever linkage, which gives the increased movement, [468] in one case with a mirror and in the other case with a stylus. I think I

(Testimony of Samuel S. MacKeown.)

pointed out that in the 2,156,519 patent that the actual record is made by using a beam of light reflected from that mirror. By the use of the word "same" I did not mean it was identical. It was just generally a similar construction.

Q. I believe you stated that the hot wire microphone measured or responded to the velocity of the gas moving through the microphone?

A. That is correct.

Q. In that microphone as used in the defendant's device, how is the gas put into motion so that it passes through that microphone?

A. Well, the gas moves up from the well and is in motion, and moves through the diaphragm into the surge chamber.

Q. But what makes the gas move up from the well?

A. The initial impulse that was originally put into the well, and the reflection back.

Q. Do I understand you to mean that when the defendant fires a shot into the well up here at the top, that the gases from that cartridge go all the way down into this well and are reflected back, and still that bunch of gas comes back and goes through the microphone?

A. Not at all; but you can speak of either the pressure component or velocity component of a wave. And there is a wave [469] of velocity, as well as a wave of pressure, initiated by the impulse and travels down. There is a difference between them. You can say that the pressure impulse is the

(Testimony of Samuel S. MacKeown.)

result of the velocity impulse, or vice versa. Both are present, and I don't think there is any great difference between them.

Q. And both that pressure and velocity component is the result of the echo returned back to the ground surface of that gunshot or the slug of gas which has been introduced into the well?

A. Yes; and they travel with the same velocity.

Q. I believe you testified on direct examination that in connection with the use of a hot wire microphone it was necessary to provide a chamber or space at the rear of the microphone in order to permit that microphone to operate; is that correct?

A. That is correct.

Q. And I believe you said that in case of a diaphragm that space was not necessary; is that right?

A. That is right. There need be no space in back of the diaphragm for the gas or air to get through. You must leave a minute space back there to permit very small motion of the diaphragm.

Q. In other words, even on the use of the diaphragm it [470] would be necessary to have some small space at the rear of the diaphragm in order to permit the diaphragm to move under the influence of this echo which comes up against it?

A. That is correct, but no space for the gas to expand into.

The Court: No space comparable to the surge chamber?

A. That is correct.

(Testimony of Samuel S. MacKeown.)

Mr. Mattingly: Q. It does not have to be as large as the space of the surge chamber, such as would have to be used by the microphone?

A. That is right.

Q. But there would have to be some space to permit the diaphragm to respond to the echo which strikes it?

A. That is right.

Q. In connection with defendant's filter, I believe you testified that in the use of the filter by the defendant the filter was employed so as to pass back to the amplifier the frequencies of the tubing collar echoes, but would stop or choke off the frequencies which did not correspond to the frequencies of the tubing collar echoes; is that a correct statement?

A. No, you have got it just reversed. The filter itself does not pass the frequency that you want the amplifier to pass, and by not passing, allows the amplifier to pass that frequency. But the filter itself does not let that frequency through. [471]

Q. Is it true that the effect of the filter on defendant's amplifier system is to raise the tubing collar echoes above the level of the other noises or disturbances?

A. It is a little bit more accurate to say that the action of the filter is to cut down the disturbance more than to cut down the signal, because the filter itself cuts everything down, but cuts the unwanted disturbances more than the signal.

(Testimony of Samuel S. MacKeown.)

Q. Then, as I understand it, the effect of the filter in the defendant's system is to leave the tubing collar frequencies at a high level, but to suppress all the other noises or frequencies?

A. Well, pretty nearly that. It actually depresses the response of the tubing collars somewhat, but depresses the others more.

Q. So that the collar frequencies or collar echoes stand out above the other frequencies that would come up to the microphone?

A. That is correct. This all works after the microphone. There is no possible action of the filter prior to the microphone. The microphone receives everything that comes, and the filter works after the microphone only.

The Court: The filter works on the electric wire attached to the microphone? [472]

A. On the electric current, after the microphone has received everything that is put in the microphone.

Mr. Mattingly: Q. The microphone receives everything and passes everything to the amplifier-filter combination?

A. That is right.

Q. And in the amplifier-filter combination the amplifier and filter act to suppress all the unwanted frequencies and leaves the tubing collar frequencies at some distinguishable point above them?

A. That is correct.

Q. Do you know whether or not this diagram that you have referred to, following page 13 in

(Testimony of Samuel S. MacKeown.)

Plaintiffs' Exhibit 11-C—that is the Field Inspection Book—exactly represents the wiring of that filter and amplifier that is used and has been used by the defendant?

A. No. I can say this, Mr. Mattingly: That I have worked with this kind of a circuit used in an amplifier in this manner. I know how it operates. The only thing I can say is that I have been informed that this is the circuit, and my experience with the apparatus confirms that information, but I do not know that this is the wiring diagram of that circuit. I have not inspected the actual wiring of the defendant's instrument which is here in court. I have not taken it apart and traced it. I have never inspected the wiring in any of the other transducers which have [473] been used by the defendant prior to the introduction of the one which is in court. I have not traced out the diagram in any of those.

Q. With the wiring that is shown on the diagram immediately at the rear of page 13 of Exhibit 11-C, would that amplifier with the filter arranged in the manner shown cause the amplifier-filter combination to have a natural period of frequency or oscillation corresponding to the frequency of the tubing collar echoes?

A. This amplifier and filter combination will not of itself oscillate, if that is what you mean. If it is improperly adjusted, and if it does oscillate, it becomes an oscillator and is no longer an amplifier.

Q. Would that circuit, that is, that amplifier-

(Testimony of Samuel S. MacKeown.)

filter combination, tend to oscillate at the frequency from which the filter is set?

A. You can do this; with any amplifier you can arrange that amplifier by making certain changes in it so it would oscillate; then it would no longer be an amplifier, and if it did oscillate, this circuit would oscillate at the frequency the filter circuit passed, but the amplifier itself, if properly adjusted as an amplifier must be, will not oscillate.

Q. When you speak of properly adjusted, what do you mean by that? [474]

A. Properly adjusted; I simply mean that there is no positive feed-back in the amplifier which will cause it to become unstable and unsuited to operate as an amplifier.

Q. I call your attention to the diagram following page 13 in Exhibit 11-C, and particularly to that part of the circuit which is shown as including the branch that extends from the right hand wire filter circuit through what appears to be a 10,000 ohm resistor, and then through a 1,000 ohm resistor; then through a movable contact; then through a resistor R-2, the value of which is not recited there. Will you state what the effect of that branch of the circuit is?

A. The effect of that branch would be in general to govern the amount of energy that is fed back from the output circuit of the amplifier through the filter through the imput circuit of the amplifier.

(Testimony of Samuel S. MacKeown.)

Q. If there was an adjustment of the position of the movable contact which is indicated by that arrowhead immediately below the 1,000 ohm resistor would there be a tendency for this filter-amplifier combination to oscillate at the frequency for which the filter is adjusted?

A. No, this whole filter circuit, including this resistance branch that you have talked about actually operates so as to stabilize the amplifier itself, and removes any tendency, or a tendency that the amplifier might have to oscillate. Let me [475] say that another way: I stated before that you could take an amplifier and adjust, or maladjust it, if you wish, so it would oscillate, and no longer would be an amplifier, but would oscillate. That is true of any amplifier. Now, if the amplifier without the filter were so adjusted then by putting in the filter you might actually stabilize the amplifier and prevent it from oscillating, the filter circuit itself does nothing to increase any tendency, if you want to use that word, that the amplifier might have to oscillate.

Q. I refer you to the description there which appears on page 13 of Exhibit 11-C, and to that paragraph which starts about half way down the page. Will you explain what is described by that, if, as you say, the circuit which is shown behind page 13 is such that the amplifier-filter combination would have no tendency to oscillate at the frequency for which the filter is set?

(Testimony of Samuel S. MacKeown.)

A. What I said before is still true; the amplifier may be maladjusted in such a way that it will oscillate. You can make that adjustment so bad that it will actually oscillate when the filter is on there. In that case it no longer is an amplifier , and if it does oscillate under those conditions it will oscillate with the frequency determined by the filter circuit; but the filter circuit itself does not increase in any way the tendency to oscillate. That must come from the amplifier, and from some positive feed-back rather than [476] negative feed-back. Negative feed-back always stabilizes the amplifier, and decreases the tendency to oscillate. A positive feed-back increases the tendency to oscillate, so all I can say here is that when the adjustment is made that was discussed here, that may cause the amplifier to oscillate, that adjustment is one which may increase the gain of the amplifier itself so much that the amplifier will become unstable, with or without the filter, and oscillate, due to stray positive feed-back, but this circuit which is shown here is definitely a damping circuit, a negative feed-back, so if anyone removes it, it decreases the tendency to oscillate. That is the property of this circuit.

The Court: What do you mean when you say that an amplifier will oscillate, and not be an amplifier?

A. An amplifier by definition can be made to osciliate.

Q. Oscillation is movement?

A. Oscillation is movement of its own free will.

(Testimony of Samuel S. MacKeown.)

I don't know whether you have ever taken the old telephone transmitter and receiver, which is an amplifier, and have taken the receiver and put it close to the mouthpiece.

The Court: I have many times, when I couldn't get the operator.

A. That is an amplifier, in which you have taken some output from the receiver and put it back into the in put [477] transformer, and have got it so it will oscillate. That is maladjustment of the amplifier. You have put a positive feed-back so there is instability, and the amplifier oscillates by frequencies which will be determined by some natural frequency in the circuit.

Q. Isn't there oscillation in the amplifier?

A. There should be none.

Q. You say oscillation is free movement?

A. Of its own free will. There is nothing needed to start it. It keeps going; what is called a self-excited oscillator. The oscillation in the amplifier means that it is not working right. It is no longer an amplifier; it is an oscillator. It is easy to take an amplifier and make it into an oscillator, as the example I gave you of the telephone receiver and transmitter.

Mr. Mattingly: Q. If the filter-amplifier is set by adjustment of the filter to respond particularly to tubing collar frequencies, then the output of that amplifier, the energy represented by the tubing collar frequencies, would be greater than the energy

(Testimony of Samuel S. MacKeown.)

of the other frequencies which would be fed into the combination, is that right?

A. If we are feeding a whole band of frequencies. What are you feeding in the beginning?

Q. Feeding a whole band of frequencies, including tubing collars. [478]

A. It will amplify that frequency more than any others.

The Court: Let me ask a question to clear it up in my mind: Does a filter have a tendency—I mean, do different filters have different tendencies to catch certain sounds and filter them out?

A. We can build a filter which will transmit certain frequencies, and exclude others.

Q. You can make it richer? A. Yes.

Q. Or you can make one that has a range which you adjust with a button?

A. Or a control.

Mr. Mattingly: Q. Is the statement which I read out of this book, 11-C, pages 13 and 14, a correct statement of the operation of this filter and amplifier set out on drawing 7506, following page 13 of that book?

A. No, it is not—at least, my understanding of this is that it is not correct, in this; if this sentence that you read means that the energy sent back through the filter tends to make the amplifier oscillate, increases the tendency of it to oscillate, that is entirely incorrect. An energy fed back through the filter would decrease any tendency that did exist

(Testimony of Samuel S. MacKeown.)

to oscillate. I did not write this. I am not in any way responsible for what is on this page. [479]

Q. My question is directed to whether or not that is a correct description of what occurs in the arrangement which is shown in the drawing 7506 following page 13.

A. I don't agree with that sentence as I understand the meaning of the sentence to be.

Q. Then you would say that the description given on page 13 is incorrect as a description of the operation of the circuit shown in the drawing 7506?

A. I think it is certainly ambiguous, and I think it gives the wrong impression of the correct one.

The Court: Is that incorrect if you read the previous sentence? It says "In addition to its switching action this control adjusts the amount of energy fed back from the output to input circuits of the amplifier. This energy causes the amplifier to have a tendency to oscillate at the frequency for which the filter is set." Is that correct?

A. No, the last sentence, I am afraid is not correct, because energy which is fed back through the filter—I am reading into that "through the filter" could not increase the tendency to oscillate.

The Court: It is exactly contrary?

A. Yes, it is entirely contrary. There may be other stray paths which could tend to make it oscillate, but that path cannot.

Mr. Mattingly: Q. Would the energy fed back through the path I have just called your attention

(Testimony of Samuel S. MacKeown.)

to through the branch [480] including the 10,000 and 1,000 ohm resistor, and the resistor R-2?

A. No, that energy is so connected that all of that energy fed back stabilizes the amplifier and removes the tendency to oscillate rather than to produce a tendency to oscillate.

Q. Now, refer to page 15 of the instruction book, 11-C, the paragraph beginning at the bottom of that page:

"When it is difficult to get good collars the feed-back control should be set so that when the transducer volume control is set at the maximum necessary for the well the push button will cause the filter to generate oscillations for not over 10 cycles. The filter will give the transducer an overall amplification somewhat greater than normal for singles of the frequency for which the filter is set. The amplification increases as the feed-back is increased. The filter will have a tendency to decrease the sharpness of the fluid, tubing catcher, and liner top breaks on the record and in some cases it will be necessary to record those points on one record without the filter and then use the filter to include the tubing collars on the record."

Is that a correct description of the operation of the circuit as shown on drawing 7506?

A. That may be when you remember that when the transducer [481] volume control is set to a maximum is one condition then the minimum energy is fed back through the filter circuit, and that the volume control on the amplifier may be increased un-

(Testimony of Samuel S. MacKeown.)

der those conditions. In other words, the maximum amplification will come when the energy feed-back is a minimum through the filter circuit, and under that condition this could be a correct statement, particularly if the other control, the volume control, is turned up very high.

The Court: Is that what you mean by decrement?

A. Decrement is decrease in the giving off of energy.

Q. The left hand control frequency is calibrated from 1 to 1,000. That does not regulate anything, does it, the frequency control?

A. The frequency control regulates the frequency which the amplifier will selectively amplify.

Q. What is a transducer?

A. A transducer is a very general term for, let us say, any box in which you put current on one side and get a current which is related to it, out of the other side. It is a very general term. It might be an amplifier; it might be a filter; but it is a very general term, which would include a filter or amplifier.

Q. All right. Now, when the switch is off the filter is entirely disconnected from the transducer. I take it that the transducer is the thing that takes the electric energy [482] through it to the filter?

A. Right through to the recorder. It includes both filter and amplifier.

Q. Then all the transducer is used, in a sense, as the whole electrical apparatus?

(Testimony of Samuel S. MacKeown.)

A. Yes, everything except say, the microphone.

Mr. Mattingly: And recorder.

A. And recorder. The microphone would connect to the input of the transducer, and the recorder would connect to the output of the transducer.

The Court: Could an amplifier be said to oscillate, if it responds to a certain beat, whether that is provided by sound or electric energy, which beat is received at a regular interval? A. No.

Q. Could that be said to be an oscillation of an amplifier?

A. No. If an amplifier responds to its input it is not oscillating. When it is oscillating it is giving out something that has no resemblance to anything that goes in at the input. It is no longer an amplifier.

Q. I understand how you change oscillation, but what I want to know is the effect of oscillation on amplification.

A. It destroys it. It absolutely destroys it.

Q. You mean you get no sound out of the amplifier?

A. No; I mean you get no sound that corresponds at all [483] with what you are trying to amplify.

Q. In other words, you couldn't set that machine to oscillate at the tubing collars?

A. Well, I could if I went inside the machine and changed it around; yes.

Q. Then it can be adjusted so that it would faithfully record the tubing collars by oscillating?

(Testimony of Samuel S. MacKeown.)

A. But it would record them whether they were there or not. I would record them in this room, whether tubing collars were there or not.

The Court: It would?

A. Yes. If you go back to the telephone, if you take that receiver and put it near the transmitter, if you try to talk into the transmitter a person couldn't hear what you said, because the other noise entirely masks it. The noise of its oscillation entirely masks it.

Q. And if you set that machine to operate at regular intervals upon the the introduction of sound or electric impulse, all there would be is the oscillation, and you would have to know in advance at what intervals you would want it to oscillate?

A. If would always give me, and it would give me in this room, if I set it up to oscillate at that frequency, although there may not be tubing collars within miles of here, it would keep on oscillating at that frequency as long as I had a battery supplying power to it; and the kick I would get would have [484] absolutely no relationship to any tubing collars. If I changed the distance between tubing collars I wouldn't change the record, at all, that I would get.

Q. They would be the same?

A. Each one of those would be exactly the same size, and continue indefinitely; and it would do that whether I put a pressure impulse in the well or didn't put a pressure impulse in the well.

(Testimony of Samuel S. MacKeown.)

Q. And that oscillograph which was taken—that would be an oscillograph, wouldn't it?

A. It would be an oscillator.

Q. That could be used to measure the lapse of time, couldn't it.

A. It could be, very beautifully. That is what your watch is. Your watch is an oscillator, but it couldn't be used to measure tubing collars.

Q. Not the lapse of time between echoes?

A. No. Those wouldn't affect it, at all.

Mr. Mattingly: Q. I will refer you to page 14 of this exhibit 11-C, which describes the way in which the filter is calibrated for frequency. Beginning at the top of the page:

"Before operating the filter it should be calibrated for frequency. The most convenient calibration curve is one of filter setting vs. record length of a cycle of the filter [485] frequency. This calibration may be made in the field by setting the feed-back control (Decrement) so that the amplifier oscillates for about 10 cycles after pushing the test button with the volume control set at about 75-Hi."——

The Court: What does that mean, 75-Hi?

A. There are two switches, one high and one low.

The Court: I see.

A. They work the volume control.

The Court: That means "high", then?

A. Yes.

Mr. Mattingly: Q. (continuing) "Records should be made of the oscillations at 10 or more different

(Testimony of Samuel S. MacKeown.)

frequency settings and the average length of cycle for each setting (taking an average of 10 or more cycles) should be plotted against filter setting."

From that description would you say that the setting of this decrement control to a certain value, and then the mere touching of the button to give the impulse into the amplifier-filter circuit, would cause the amplifier to oscillate for 10 cycles and then stop?

A. The amplifier would give you those oscillations for 10 cycles or more, but it would not be what I have defined as an oscillator.

Q. If the decrement were set at that same value and you [486] received a series of 10 tubing collar echoes at that same frequency for which you had set the filter, wouldn't the amplifier operate to amplify those tubing collar frequencies?

A. Yes.

Q. And with the filter set at that same value that we have spoken of in the last few questions, wouldn't the filter then have a natural period of oscillation corresponding to the frequency of the tubing collar echoes?

A. Yes, it would.

The Court: What you mean is that it can be set so that it oscillates and records the tubing collar echoes?

A. Well, maybe I can explain. Let's think of a pendulum in a grandfather's clock. That pendulum is not oscillating, but it has a perfectly natural frequency of oscillation because of its length, and if it starts oscillating, it will oscillate with that fre-

(Testimony of Samuel S. MacKeown.)

quency. I think what Mr. Mattingly asked in his last question: It is a pendulum not moving, but it has a natural frequency of oscillation because of the structure, and if it does oscillate it will oscillate at the natural frequency.

Mr. Mattingly: Q. Dr. Mackeown, I think on your direct examination you stated that patent 2,156,519 was directed to the use of a pressure impulse? A. Yes.

Q. Do I understand your testimony to mean that that [487] patent is directed to the use of the pressure impulse created only by the injection of a slug of gas from the pressure chamber shown in the Walker patent 2,156,519?

A. I think this patent discloses the use of a pressure impulse, which can be nicely adjusted as to its magnitude and other characteristics. There are six places in the patent which describe the pressure impulse or its manner of response. Those places are page 3, column 1, at line 22; page 4, column 1, at line 35; page 4, column 1, at line 63; page 4, column 2 at line 42; page 4, column 2, at line 71, and page 5, column 1, at line 29. All of these places refer to the necessity, as I understand it, or certainly the desirability of being able to adjust this pressure impulse to obtain the desired record and the necessity of doing that, and, I think, as I understand the patent, an impulse chamber or some like device in which the pressure can be accurately adjusted to give the desired characteristics.

(Testimony of Samuel S. MacKeown.)

Q. You did not mean, then, by your statement, that the patent is directed to or limited to the use of the pressure impulse, that the patent excludes the use of a gun shot, did you?

A. I think it does. For instance, Mr. Mattingly, let's take several of these references. Let's take the one on page 3, column 1, at line 22:

"The only item which must be provided for is that of [488] producing a pressure wave echo of such magnitude and such character that the echo from the tubing catcher can be distinguished from the echo received from the fluid surface."

Q. What part of that statement that you have just read excludes the use of a gunshot?

A. I don't see how you can change the magnitude and character of a gunshot to give any desired changes that may be required. I think if you fire a shot you are stuck with whatever pressure impulse that shot gives, and you have not any ability to change the impulse that you get. There are a good many other places, as I have mentioned, where I think that is brought out even better—the desirability of being able to regulate the pressure impulse that is used. Let me refer, for instance, to the patent at page 4, column 2, at line 42, which states:

"Thus by observing the effects of a series of pressure impulses of different intensity or pressure, the operator may determine which impulse is most desirable to produce the distinctly recognizable and differentiatable peaks *c* and *d*, allowing him to dif-

(Testimony of Samuel S. MacKeown.)

ferentiate between echo from the tubing catcher and the echo from the fluid surface."

There I think it does require this adjustment that I was speaking of.

Q. Now, Dr. Mackeown, do you know whether or not the [489] defendant in its practice always uses the same size of shotgun shell or same size of cartridge in producing the pressure impulse used by the defendant?

A. I don't know, but I understand it does not use the same size shell.

Q. Isn't it true that they use in some instances a 10-gauge shotgun shell and in the other instances use a .38 caliber pistol shell, and in the instance used in the court room here a .22 caliber shell?

A. I understand in practice that they use either a No. 10 shotgun shell or a No. .38 cartridge.

Q. And each of those different shells would produce a pressure impulse differing in magnitude from the other; is that correct?

A. Each one would produce a different impulse; that is correct.

Q. Then the shells of one or another of those cartridges would constitute a selection of the magnitude of the impulse, would it not?

A. I don't think so. By that I mean, Mr. Mattingly, that with the defendant's apparatus there is no necessity of selecting any impulse of particular magnitude. The magnitude of the impulse can be compensated for by the change of the setting of your amplifier. And the defendant's apparatus is

(Testimony of Samuel S. MacKeown.)

not capable [490] of differentiating between a positive and negative pressure impulse. I understand, again, the No. 10 shell is suitable for all work. I understand they don't use it for shallow wells for two reasons: The .38 blank is a little cheaper, but more important than that, there is less smoke coming up to the microphone and the parts inside by the .38 blank than there is from the No. 10.

Q. That is your understanding. Have you been told that by the defendant and employees of the defendant?

A. I have been told that by the defendant, and it seems reasonable to me.

Q. Do you know whether or not there are conditions existing in these wells, which are tested by the defendant, under which the firing of the 10-gauge shotgun shell will produce a record which is mangled up by reverberation noises and hash resulting from the firing of the 10-gauge shotgun shell?

A. All I can say is what theory would indicate, if that is what you wish. Theory would indicate that assuming we have a fairly rigid structure, such as any tubing and casing, then the magnitude of your impulse would not increase or decrease in any way the reverberations, the per cent of reverberations. In other words, what we might call the ratio of a signal to noise, the desired signal to reverberations, or other things produced by the impulse, should be independent of the magnitude [491] of the impulse. Your disturbances would be proportional to the impulse. And I would expect that there would be no differ-

(Testimony of Samuel S. MacKeown.)

ence in the gas in the pipe, the thing received by the pressure diaphragm or the microphone, there would be no difference in the ratio of signal to disturbance as you change the magnitude of the impulse.

Q. You have never actually used the defendant's apparatus in making commercial tests in oil wells, have you?

A. No, I have never used it in making commercial tests.

Q. The condition, such as I assumed in my previous question to you, could exist, could it not?

A. It could. And I could say this: That at Duncan we made a whole series of tests where we changed the impulse, using an impulse chamber from some 10 pounds to over 100 in exactly the same well. Everything else kept constant, and I don't believe you could tell one record from the other. The amplifier was changed each time. I think you will find the same ratio of signal to noise, signal to disturbance, on each one.

Q. But all those tests were conducted on one well; is that right?

A. That is right.

The Court: As I understand, the use of the amplifier eliminates any necessity for delivering a larger or smaller pressure impulse in a well according to its depth or size? A. Yes. [492]

Q. In other words, if the implse is slight the amplifier can pick it up, and if it is greater it can diminish it?

(Testimony of Samuel S. MacKeown.)

A. That is right, with a single exception: It should be large enough so that it will keep other noises, such as pump noises or other things relatively small.

Q. It should be greater than——

A. Than outside disturbances. As long as it is big enough there is no need of cutting it down, and that is all you need.

Q. I see. Is there any reverberation that comes back and forth across the well as it is going down in the pipe?

A. They would die out quickly. In the beginning there might be, but as you go down a short distance they will be what we say damped out very quickly and they will be absorbed by the repeated reflections back and forth.

Mr. Mattingly: Q. I refer you to the plaintiff's patent, 2,209,944, and call your attention to claim 7 of that patent. That claim is directed to the selection of the magnitude of the impulse which is to be used; is that correct?

A. It is directed to even more than that. It is directed to first making a series of tests, and from that series of tests picking out the impulse which will give you the desired results.

Q. Now, do you find any statement in any of the other claims of that patent which are limited to the magnitude of the impulse? [493]

A. Yes, I think I do. Claim 3, for instance. May I read the part——

Q. Yes. A. The first part.

(Testimony of Samuel S. MacKeown.)

"The method of determining the unknown loc tion of an obstruction in a well having a string tubing therein, which consists in creating an accou tical impulse in the annular space between the tu ing and the well casing of such magnitude as co pared with the depth of the well and the resistan to pressure wave transmission therethrough as w produce echoes from portions"—and so fo th.

That part I have read, I think, requires the s lection of an impulse of proper magnitude. An I think most of the claims actually do call for ju such a kind of an impulse."

Q. Will you please point out where, in eith of the claims you find any such statement?

A. In claim 2 it states: "which consists in crea ing an accoustical impulse in the annular space b tween the tubing and the well casing to produ echoes from portions of the tubing string disti guishable from each other and from the echo fro the unknown obstruction,"

I think the requirement there that the accoust cal impulse is to produce these distinguishab echoes requires, in view of what the teachings the patent are, that the impulse be adjusted to th proper magnitude and character to do that. [49

Q. That does not say that in that claim, thoug does it?

A. I think it says it. As I understand, the a coustical impulse is to produce these distinguish able echoes, and the patent tells you how to d

(Testimony of Samuel S. MacKeown.)

that; that you must adjust the pressure impulse to do that.

Q. I believe you stated that in defendant's apparatus there is nothing which will produce distinguishable echoes, is that correct?

A. I thought I said there was nothing which will register the distinguishable echoes.

Q. Doesn't the defendant's apparatus produce echoes which are readily possible to distinguish between fluid level echoes and echoes in the tubing collars?

A. Not as I understand the claim there, but any character- [495] istic of a single wiggle itself.

Q. Do you find anything in this claim which specifies the characteristic of the wiggle?

A. I think so.

Q. Point it out.

A. "to produce echoes from portions of the tubing string distinguishable from each other and from the echo from the unknown obstruction."

Now, the echoes themselves, each by itself, is, I understand this to mean, distinguishable in its characteristic from the other; not in its location along the well, but in its characteristic.

Q. Will you find any place in the specification of the patent where "distinguishable" is used in the sense that it has to be a characteristic of the wiggle; that is, whether or not it is a positive or negative wiggle?

A. Yes, I think there are just such places, Mr. Mattingly.

(Testimony of Samuel S. MacKeown.)

Q. Patent 2,209,944 we are referring to now?

A. Yes.

I have found my references, Mr. Mattingly, this 2,209,944 patent that I think teach that t pressure impulse should be adjusted to give th distinguishable echo; that is, so that the echo i self can be used to identify whether you have tubing catcher, fluid level, or some other type obstruction.

Q. That I don't believe was the question whi I asked [496] you. Mr. Reporter, will you read t question to the witness?

(Question read by the reporter.)

A. Let me refer to page 4, column 2 at line 2 which reads:

"Thus by observing the effects of a series pressure impulses of different intensity or pre sure, the operator may determine which impulse most desirable to produce the distinctly recogni able and differentiable peaks *c* and *d*, allowing hi to differentiate between echo from the tubing cat er (or such other obstructions as may be know to be in the well) and the echo from the flu surface."

Q. Where does that mention anything about t positive or negative wiggle?

A. It describes the echoes arriving from t different obstructions as distinctly recognizable a differentiable, and to me means that they have characteristic which allows you to distinguish

(Testimony of Samuel S. MacKeown.)

the characteristic the type of obstruction which is causing those echoes.

Q. And you think that that characteristic that you have referred to is that it must be a positive or negative wiggle in the line?

A. I think that is one of the characteristics; there may be more. In other words, if we have a tubing catcher with a pressure responsive device then you do get a positive pressure wave when you hit the top of that tubing catcher, and a negative pressure or rarefaction wave when you leave the bottom of that catcher. Now, they can get a distinguishable characteristic on a pressure responsive device which cannot be obtained when you use a device like the hot wire microphone, which cannot distinguish between a pressure and rarefaction wave. [497]

Q. Then the thing which distinguishes, as you have used the word "distinguish" is whether or not there is a diaphragm or a hot wire microphone used to receive and record the echoes?

A. As I understand the patent there are two things to get that. One is that the recorder be a pressure response device, such as can have that property, and, in addition, that the pressure impulse be adjusted to the right magnitude to give that kind of echo.

Q. Now, will you tell us under what condition can the pressure impulse be so adjusted as not to produce on a diaphragm type of instrument the negative and positive wiggle?

(Testimony of Samuel S. MacKeown.)

A. I don't know. I did not write the patent. That's what the patent says.

Q. On the records which are produced by the defendant, can you distinguish between tubing collar echoes and tubing catcher echoes?

A. You can, yes. You can, simply because the magnitude of the tubing collars is smaller in general than the magnitude of the tubing catchers or fluid surface, but there is no characteristic wiggle, let me say, or shape of the wave that allows that.

Q. I believe you stated also that the defendant's apparatus does not measure the time between the injection of the [498] shot into the well and the receipt of the echoes from the various obstructions back from the well.

A. That is true, as I understand their method.

Q. Do I understand by that that you mean that the defendant's recorder does not record the lapse of time between the creation of the impulse and the receipt back of the echoes?

A. That is correct, and no calculation or determination of the lapse of time is made.

Q. Do you understand how the defendant's recorder operates? A. Yes.

Q. What causes the movement of the paper lengthwise through the defendant's recorder?

A. A small motor.

Q. And is that small motor driven at a constant speed? A. Yes.

Q. Is there any means provided in the defend-

(Testimony of Samuel S. MacKeown.)

ant's recorder for making that tape move at constant speed? A. Yes.

Q. Then in a given interval of time, say, one second, there will be precisely so many inches of that tape moved past the pen, will there not?

A. That is true.

Q. When you say this does not measure time, or record time, do you mean that it does not record the time in units of minutes [499] or seconds or hours?

A. It does not record the time. That paper, I don't know how fast it moves. I know it moves at a constant rate, but I do not know how many inches it moves per minute. I understand their operators do not know, they don't have to know, and they don't care. You can make a calibration and use it for measuring time, but it is not done.

Q. In the defendant's apparatus, the feed of that paper is so many inches past the pen in a given interval of time?

A. Yes, that is true, and that is a constant speed.

Q. The space of those wiggles along the chart on a constantly moving paper represents the time interval at which the echoes are received back at the ground surface, does it not?

A. Yes, in an unknown unit, if you wish.

Q. And the measure of time does not necessarily have to be in a known unit, does it?

A. I think so. For instance, I can't tell you by looking at any one of these charts what the time is

(Testimony of Samuel S. MacKeown.)

between any two marks on it, because I don't know what the speed is.

Q. By that you mean that you don't know the time in units of seconds or tenths of seconds?

A. Or any unit of time.

The Court: The way they determine that is knowing the tubing lengths?

A. That's the way it is determined, by comparing the known [500] distance rather than the time.

Mr. Mattingly: Q. Then the distance along the tape made by the defendant between the shot, for example, and the echo from the tubing catcher, represents the lapse of time between the shot and the time the echo came back from the tubing catcher?

A. It can represent the lapse of time in arbitrary unknown units.

Q. Throughout the trial of this case I believe you and various other witnesses have referred to the slope of the line on these various charts that we have referred to, and just for the purpose of the record, the slope of that line is a graphic representation of a fraction is it not?

The Court: Why don't you just leave it "slope"? I know what a slope is, but I don't know what a graphic representation of a fraction is.

The Witness: I don't either.

The Court: As I understand it, it is carrying out the condition based upon two or three known factors, or two known factors, rather; you have pressure and depth at two different places or three, and all you do is to assume that they are the same and carry them out?

(Testimony of Samuel S. MacKeown.)

A. That is correct.

Q. That is what they call extrapolation?

A. Yes.

Q. That is ordinate and abscissa? [501]

A. When you extend any experimental result by graphical or other method beyond the range which those experimental results have taken, that is called extrapolation.

Q. In other words, beyond the known range?

A. Yes, that's right.

Q. Sometimes you refer to that as a curve, even though it may be straight?

A. Yes, because when we plot, using ordinate and abscissa, we often get a line which is not a straight line but a curve. In general, we speak of a curve there which may be a straight line.

Mr. Mattingly: Q. I have here a book on plane analytic geometry, and I refer you to page 28 of that book.

Mr. Graham: Who is that book by, and when was it published?

Mr. Mattingly: The book is by Harding and Mullins, and was published in 1937 by MacMillan Company.

The Court: What is it, a standard text book of some kind?

The Witness: Yes, it is a plane analytical geometry.

Mr. Mattingly: Q. The statement is made on page 28 of that book that the slope of the line represents an equation——

(Testimony of Samuel S. MacKeown.)

Mr. Graham: Let us have the words there from the book, if you don't mind.

Mr. Mattingly: Represents an equation in which the value of the slope equals $\frac{Y_1 - Y_2}{X_1 - X_2}$, is that correct?

A. That is correct, where Y_1 and X_1 represent the ordinate and abscissa at one point in the curve, and Y_2 and X_2 represent the [502] ordinate and abscissa on any other point of the curve.

Q. And as represented on the chart shown in patent 21,383, the slope of the line represents——

The Court: The slope of the extrapolated line?

Mr. Mattingly: The slope of the line prior to extropolation, that is, the part of the line which connects the several points that are actually measured, that slope represents the difference in two pressures; that is, we can say that the pressure is represented by Y—that would be $Y_1 - Y_2$ over the difference in the height of the fluid level, which we might call X, and represent that by $X_1 - X_2$, is that correct?

A. That is correct.

Mr. Graham: Let it appear in the record that counsel has been referring to Figue 3, in patent 21,383 in suit; that is the reissue patent.

The Court: All right.

Mr. Mattingly: One more point, Dr. Mackeown. In your testimony you were asked whether or not the defendant determines the density in its operations. I believe you stated that the defendant did not determine density, and you continued your answer that the defendant did not calculate the density. Now,

(Testimony of Samuel S. MacKeown.)

do you draw any distinction between the word "determine" and the word "calculate"?

A. No, I did not mean that. They don't in any way find the density. They don't know what the density is, either by calculation or measurement, or combination of the two. [503]

Redirect Examination

Mr. Graham: Q. Doctor, will you make a short, consice statement of the effect of the filter-amplifier combination as used in the defendant's device?

A. The filter-amplifier combination in defendant's [504] apparatus, is a piece of equipment which can be tested to selectively amplify the echoes in the tubing collars. Neither the amplifier nor the filter contain a tuned circuit or a resonant circuit. And the selective amplification is obtained by having the filter control the gain of the amplifier.

Mr. Graham: Your Honor, we have had this defendant's apparatus in court and, also, the pieces of apparatus that were used in Duncan in making the experiments in the Wyatt and Lehr patent. We would like to have those removed. One of our men has been here a couple of times to take them away, but counsel has said he might want them for something or other.

The Court: Do you now wish them?

Mr. Mattingly: I don't believe so, your Honor. If the defendant is willing to stipulate that the commercial apparatus, which has been used by the defendant prior to the manufacture of the device in court, is exactly the same as the device which is in Court——

(Testimony of Samuel S. MacKeown.)

The Court: What is that?

Mr. Mattingly: The defendant in this case has used two different pieces of apparatus—two different types of apparatus.

The Court: Well, he used the Wyatt and Lehr experimental apparatus. Is that what you mean?

Mr. Mattingly: No; I mean in their commercial operations, the defendants have used, as defendant's apparatus, two different types of apparatus. One of those was the kind of apparatus in [505] which the recorder was in a separate box from what they have termed the transducer, whereas, in the piece of apparatus which is in court here the transducer and recorder are all in one box.

Mr. Graham: Well, is that material?

Mr. Mattingly: I only want to know whether or not the defendant is willing to stipulate that, in so far as this case is concerned, both those types of apparatus are the same.

The Court: That is, that they are identical but housed differently?

Mr. Graham: One is in one box and the other is in two boxes.

Mr. Babcock: They aren't absolutely identical. I know one change was made in the recorder.

Mr. Mattingly: But as far as affecting the purpose of this case?

Mr. Babcock: As far as affecting the purposes of this case I think we can stipulate.

Mr. Mattingly. That is all right. Then, I have no reason to ask the defendant to keep the apparatus in court. [506]

HOWARD C. PYLE

a witness for the defendant, testified as follows:

My address is 617 West Seventh Street, Los Angeles, California. I am employed by the Union Oil Company of California as their chief production engineer. With the exception of a little over a year during 1932 and part of 1933, I have been with the Union Oil Company since January of 1927. I have a degree of Bachelor of Science from the University of California, in petroleum engineering, college of mining; degree of Master of Science from the University of Southern California, and a degree of Petroleum Engineer from the University of Southern California. I am a member of Sigma Xi and Beta Tau; the American Institute of Mining and Metallurgical Engineers; American Association of Petroleum Geologists; American Petroleum Institute. I am familiar in general with the Depthograph and Echo-Meter, and the uses to which they are put in the oil fields. The Union Oil Company uses both the Depthograph Company, and the Halliburton Oil Well Cementing Company, which operates the Echo-Meter. I have been familiar with the Depthograph and the Echo-Meter very generally since commercial work started with both of those. I am not sure as to the exact dates, but I would think it would be 1935 or 1936, approximately.

Mr. Babcock: Q. Did the Union Oil Company itself ever use any sonic methods to locate fluid levels?

A. I am not specifically familiar with their early

(Testimony of Howard C. Pyle.)

work, [507] though I have talked with the people who did the first work.

Q. When did you first get any knowledge that anything had ever been done by Union?

A. In the year 1935 or 1936 I had occasion to talk to several of the people who worked with the methods of 1927 and 1928, I believe, and had occasion to read the files that were available to our company on the subject.

Mr. Babcock: I will ask that these documents be marked for identification; first a drawing which bears date April 6, 1928, Union Oil Company of California, drawing No. RDS 176, and ask that that be marked defendant's exhibit P. All of these are photostats, by the way. The next is a photostat of a sheet which bears the heading: Determination of the oil levels in wells by sound signals; and it is signed Edson R. Walcott, May 16, 1927; that will be P-1.

The next is a four-sheet document. It is in the form of a letter on Union Oil Company of California stationery, dated April 6, 1928, to Philip Subkow, patent engineer, and signed in typewriting W. A. Raine, manager research and development, by E. R. Walcott. That will be P-2.

Q. I hand you these documents, marked P, P-1 and P-2, and ask if you can identify them.

A. I can identify them as being on Union Oil Company stationery. I am familiar with the signature of Mr. Walcott, [508] and one of the witnesses, P. H. Jones.

(Testimony of Howard C. Pyle.)

Q. When did you first see these documents or the originals from which these were photostated?

A. I am confident that these were in the Union Oil Company's patent department and research and development files when I examined those files probably in 1935 and 1936. I am not sure of the date. I am familiar generally with the work these men did, as a result of an examination of the files and with talking with some of the men.

Q. I understand, then, that in 1935, or at about that time, you learned that the Union Oil Company had done some work on the use of sound to locate fluid levels?

A. That is right.

Q. Can you state briefly what it was you learned they had done at that time? Was that the first you knew that they had done anything along this line?

A. Yes; as well as I remember it is. Back in 1926 or '27 Mr. Rubel, presently vice-president of the Union Oil Company, and at that time an engineer at one of the Union Oil Company oil fields, the Dominguez oil field, did some experimental work in the determination of fluid levels in oil wells. I am familiar with this through his own accounts to me. And it was these accounts of his that caused me to look through the files of the company to become more acquainted with the work that followed [509] this earliest work of Mr. Rubel.

Mr. Mattingly: Your Honor, I must object to the witness testifying here as to what work was done

(Testimony of Howard C. Pyle.)

by the Union Oil Company, since he has learned it only by hearsay.

The Court: Your objection is good.

Mr. Mattingly: He may testify as to what knows.

Mr. Babcock: Yes, that is what I meant to bri out, your Honor, what he learned in 1935; what knowledge was in 1935.

The Court: Well, counsel is objecting to h learning from somebody else that somebody else some work in 1927.

Mr. Babcock: Yes.

The Court: Well, proceed.

A. I think I have recounted it. I merely talk to the men, most particularly with Mr. Rubel, abo that early work, and read the files. I had no fi hand acquaintainship and was not in the part of t country during that period of time, although I w in the employ of The Union Oil Company.

Mr. Babcock: Q. Let's start from 1935. Gi the historical development in the Union Oil Co pany, if there was any development in the sou methods for locating fluid levels, to which you have direct knowledge and in which you took pa

A. Well, Mr. Rubel, as I said, acquainted m with the early work that he had done and told m that he had discussed [510] this work with Dr. J kosky; that Dr. Jakosky was much interested in and asked me to cooperate with Dr. Jakosky in t event that he chose and decided to become active the development of oil field tools or equipment f

(Testimony of Howard C. Pyle.)

the measurement of fluid levels. I had known Dr. Jakosky before. Dr. Jakosky developed the instrument that is referred to as the Echo-Meter, and the Union Oil Company provided wells on which the instrument could be checked during the period of development.

Q. Did you take any part in that development?

A. No. I was just generally familiar with it; and the development and the testing of the equipment proceeded in the field and was conducted, as far as Union Oil Company personnel were concerned, by engineers who were under my direction at the time.

Q. Why were you or the other engineers of the Union Oil Company interested in developing a sound method of measuring fluid levels or in seeing such development?

A. Well, we had long been interested in the development of bottom hole pressures as a guide to the determination of production performance of oil wells, and we found that in many cases, particularly as regards to pumping wells, that the pressure and measuring equipment was not only expensive, but had a high maintenance cost and we were interested in any means of accomplishing the end of pressure measurement [511] economically for a lesser cost than by pressure gauges.

Q. I gather, then, that prior to 1935 you had done some work with pressure gauges?

A. Yes, that is right. We had become interested in bottom hole measurements in 1933, and our first

(Testimony of Howard C. Pyle.)

work in that connection was, if I remember rightly in December of 1933. I am quite sure of that date That work was first in connection with the measurement of pressure under known producing conditions in oil wells. Subsequently the work expanded to the measurement of pressure while wells were producing; both first for flowing wells and later for pumping wells.

Q. Where was that work?

A. Well, the first work that the Union Oil Company did was, I believe, in their Stearns property in the LaBrea-Linda district. The first extensive use in California of pressure methods as a means of determining the productivity of a well was a cooperative effort in the Kettleman-North Dome field made at the request of the N.R.A. That was in 1935. The various operators in the state by that time had, almost without exception, become interested in bottom hole pressures and measurements and in a cooperative way they joined forces and measured the productivity of all the wells in the field. If I remember rightly, there were approximately 200 wells there at that time.

The Court: Were those flowing wells? [512]

A. Yes.

Q. How were they measured?

A. With a bottom hole pressure gauge.

Q. How did you lower it?

A. On a wire line. I personally took part in that. The work was conducted through a committee. I don't just recall now whether it was appointed by

(Testimony of Howard C. Pyle.)

the Central Committee of California Oil Producers or by the representative of the N.R.A. I was on that Committee and participated both in the outline of the work and made frequent visits to the field to observe the conduct of the work.

Mr. Babcock: Q. Does the Union Oil Company still today use a pressure gauge or a pressure recorder to record bottom hole pressures?

A. Yes, we do a great deal of work in that connection. We have a small group who devote their time exclusively to that type of work.

Q. Which is the more accurate way of determining bottom hole pressures, a pressure recorder or these instruments which use the sound or pressure impulse such as a Depthograph or Echo-Meter that measure fluid levels?

A. In my opinion the pressure gauge is the most accurate known method of measuring the bottom hole pressure.

Q. Are there any others besides a pressure recorder or a [513] Depthograph or Echo-Meter for determining bottom hole pressures?

A. I think so. There are a number of methods that have been used for determining pressures in oil wells. The earliest methods were done crudely by lowering a bailer in the well for determining where the fluid level started in the well. Subsequently pressure bombs were used. They were not of the recording type, but were merely closed bailers with a check valve in the bottom. They were lowered into the well and then brought to the surface and they would

(Testimony of Howard C. Pyle.)

attach an ordinary surface gauge to it and measure the pressure; that is, there were subsurface pressure gauges which we used, which are wholly self-contained. There was an early method developed of lowering hollow tubing, and finding the pressure required to inject gas out of the bottom of the tube, which was directly related to the pressure. Then, there are these fluid level methods for determining the fluid level in wells, which can be related to the early work of lowering a bailer into the well.

The Court: You mean compared to the early work? A. Yes.

Mr. Babcock: Q. By early work, what dates do you have reference to?

A. I am distinctly not an old timer in the business. I know that the measurement of pressures by determining fluid levels with a bailer was discussed in 1925, when I was in college, and I associate it with a very much earlier date [514] than that. I have known that the bottom hole pressure could be calculated from a determination of the fluid level since 1935 or 1936.

Q. Are you familiar with what is called the Dice's formula for calculating the weight of a column of gas? A. Yes, sir, I am.

The Court: Let me see if I understand you. In 1925 you knew that you could determine bottom hole pressure by determining the height of the fluid level in the well, did you? A. Yes, sir.

Q. How would you do it?

A. The well's productivity is related to the pres-

(Testimony of Howard C. Pyle.)

sure opposite the producing formation, and pressure is expressed by the amount of back pressure, one might call it, against the formation, and that is determined, and varies with the fluid level.

Q. In the well?

A. Yes, sir. It is the measurement of this fluid level in the well, or the determination of whether or not there is fluid in the well, which preceded and prompted the development of sub-surface pressure gauges.

Q. If you can determine the pressure, the bottom hole pressure from the fluid level, why was it necessary to have a pressure gauge? Why didn't you just put a plumb down there and measure to the top of the fluid level? [515]

A. The answer to that, your Honor, is that the earliest measurement of fluid level by bailer is confined, and was confined wholly to wells without surface pressure. In other words, the well was just opened so that the bailer could be run in; and the work has been extended and interest has centered about wells of greater productivity. There was considerable surface pressure, and means had to be provided to get a pressure instrument that works or measures in wells that had to be closed in to confine the gas in the well under pressure.

Q. Why didn't you run pumping rods down the well?

A. Very seldom do they run pumping rods into wells with pressure. It can be done, and is done.

Q. They don't pump?

(Testimony of Howard C. Pyle.)

A. There is no surface pumping. The well is open. We are interested in the so-called measurement of pressure in flush wells or flowing wells. In all these wells you cannot open up the surface of the wells without the wells flowing.

Q. How do you use the bailer?

A. We run that in what we call a lubricator.

Q. Why couldn't you run in any other instrument, such as a plumb bob, or a wire?

A. You could.

Q. Can't you just put an instrument in there, a piece of lead? [516]

A. And feel the fluid level?

Q. Yes.

A. That would be very difficult, for one thing, in order to avoid leakage. You have so much friction on your line, your wire is not straight, so the line would hang on the side, you lose sensitivity, and you can't distinguish.

Q. Don't you do that with a piano wire in a depth pressure recorder?

A. No; the recording of pressure by fluid level is incidental to that.

Q. Doesn't the wire get stuck?

A. It doesn't get stuck, but you lose sensitivity. It is very difficult with a pressure gauge to identify the position of the fluid level as you run into the well.

Q. I understood a while ago, you to say you knew you could determine bottom hole pressure from the

(Testimony of Howard C. Pyle.)

fluid level, since 1935; now you say that you knew that since 1925.

A. There is a distinction, your Honor. I may say that I knew we could determine fluid level as early as 1925, in that I had felt that that was nothing new at that time, but my interest and my understanding of the matter did not go beyond the fact that that was a fluid level and that was that. In 1935 was when I knew—1935 and 1936 was when I knew that you could determine bottom hole pressure by fluid levels. [517]

The Court: I understand, but you can't do it without any variables and just from one measurement? A. You can approximate it.

Q. How would you approximate it, for example, a hundred barrels a day, 100 pounds pressure at the casing head, 3000 feet to the surface and a 5000 foot hole?

A. Well, you would start by adding the pressure in the casing of the well. At the top you have a hundred pounds. Of course, you would have a 3000 foot column of gas. You would evaluate the weight of that column of gas. That can be done by calculation. So you would have a 2000 foot column of oil and you would calculate the weight of that column of oil.

Q. Do you know that it is oil?

A. Well, I qualify my answer. Under some conditions you could approximate it.

Q. All right. We will assume it is oil.

(Testimony of Howard C. Pyle.)

A. All right. Then, do you want to know the variables that would influence that?

Q. Yes, if there are any. I am asking. I don't know.

A. Your Honor, you can approximate the bottom hole pressures. It is commonly done.

Q. Well, let's see. You take the 100 pounds pressure on the casing head? A. Yes.

Q. And you add to that the weight of the column of gas [518] 3000 feet high?

A. Say that would be 20 pounds.

Q. 20 pounds. Then you have got a pressure of 120 pounds at the fluid level? A. Yes, sir.

Q. All right. And you have 2000 feet of oil?

A. Yes.

Q. And you know what that weighs. What is that?

A. Well, 35 pounds per hundred feet, or 30 pounds.

Q. So you multiply 2000 by 35. That would be 700 pounds. That would be 820 pounds?

A. Yes, sir.

Q. Is that what you would approximate the bottom hole pressure at. Would you make any allowance for the gravity of the oil?

A. The allowance for the gravity of the oil, the amount of water that came up in the oil—well, we assumed it was all oil—the effect of the temperature on that oil, were all made in the 35 pounds per 100 feet.

Q. That is all in there? A. Yes.

(Testimony of Howard C. Pyle.)

Q. So, having those factors you would say that the bottom hole pressure would be approximately 820 pounds? A. Yes, sir. [519]

Mr. Babcock: Q. In this 2000 foot column of oil that you have just been discussing, in its assumed condition in an ordinary well, or in the average well, I might say, is the density or gravity of that column of oil likely to be constant?

A. Well, we are sort of compounding a whole series of estimates and assumptions here. And to answer that I would have to further qualify the thing. The first thing, one would almost have to make this under a spot determination, and it depends upon whether gas is coming up through the oil in appreciable quantities, and it would depend upon whether there was water mixed with the oil and is itself heterogeneous or stratified. And if you want me to make those qualifying comments on it I will try and answer the question.

Q. Well, what is your opinion as to whether the density in this assumed well would be the same, the density or the gradient of the fluid would be the same at the top of that 2000 foot column of oil as it is at the bottom?

Mr. Mattingly: I object to that question, your Honor, unless the question is further qualified by wh er there is a pump in the well, whether the pump is operating, and whether this column of oil that counsel is speaking of is merely a static column of oil in a static well.

The Court: Objection overruled.

(Testimony of Howard C. Pyle.)

A. And with these qualifications, I would s
that if it [520] were in a static column of oil th
the density would be approximately constant.

Mr. Babcock: Q. Well, let us answer counse
question then. What about in a pumping well, a
suming this column of oil we are talking abou
and there is any annular space between the tubi
and the casing, and suppose there is gas comi
up through it?

A. And it is producing? It isn't a static co
umn?

Q. No; it is a producing well; a pumping wel

A. Well, the density of the mixture would i
crease slightly with depth. In this first-mentione
example of a static column, oil is slightly compre
sible, so that with an increase in depth the oil b
comes compressed and more dense. Now, if yo
make it a flowing column, and disregarding for th
moment friction, gas is quite compressible, as w
know, and as you increase the depth you increas
the pressure, and for constant mixture your ga
occupies less space and your total mixture is mo
dense.

The Court: Does that mean that it is denser th
farther down you go in a pumping well?

A. Yes, sir.

The Court: Well, the same thing is true of
pumping well as a static well?

A. Yes; but for the mixture with gas it is tru
to a greater extent than it is for a mixture unde
static conditions.

(Testimony of Howard C. Pyle.)

The Court: And the variableness of the density would be greater in a pumping well than it would be in a static well? [521]

A. In a pumping well, yes, sir, producing appreciable quantities of gas.

Cross Examination

By Mr. Mattingly:

Q. When did Mr. Rubel tell you about the things that Mr. Jakosky was doing and ask you to cooperate with Mr. Jakosky on the working out of whatever it was he did?

A. To the best of my remembrance it was during 1935 or 1936, as I said before.

Q. Can you fix that date a little better? Wasn't it late in 1936?

A. I am afraid I can't fix it. I have no yardstick with which to refer to it in my mind.

Q. Perhaps you could fix it by the date on which you first became acquainted with the Depthograph methods and apparatus. When did you become acquainted with those?

A. To the best of my knowledge that was prior to this discussion.

Q. You became acquainted with the Depthograph apparatus and method prior to the time Mr. Rubel asked you to cooperate with Mr. Jakosky?

A. Yes, sir.

Q. Did you at that time know what the Depthograph methods of determining bottom hole pressures were?

(Testimony of Howard C. Pyle.)

A. I think I was generally familiar with it.

[522]

Q. And you were familiar with the fact that the method consisted of obtaining a fluid level at one gas pressure in the well, and then changing the gas pressure, obtaining another fluid level in the well, and from the relation of gas pressures to fluid levels calculate the bottom hole pressure?

A. I don't believe that I could say that I was that familiar with the method. I could say that I was familiar with the Depthograph equipment and procedure to determine fluid level. I cannot recall the details of the process of measuring bottom hole pressure that you speak of.

Q. At the time you became acquainted with the Depthograph methods and their apparatus, the Union Oil Company was not at that time engaged in obtaining fluid levels or bottom hole pressures by the use of fluid levels independently of the Depthograph Company, were they? A. No.

Q. Have you any idea why Mr. Rubel wanted you and Mr. Jakosky to cooperate with each other on the development of a sound fluid level finding device?

A Well, I had a discussion jointly with Mr. Rubel and Dr. Jakosky. Mr. Rubel had told Dr. Jakosky and he again stated it to me of his early interest and work with the measurement of fluid level in wells. And he told me that he had discussed this with Jakosky and that Jakosky was very much interested [523] in this early work; and

(Testimony of Howard C. Pyle.)

requested that should Jakosky become interested to the extent of the development of equipment would I see that the wells and engineering personnel, as required in connection with making tests of any equipment that might be developed, were provided for Dr. Jakosky. The reason for what was stated, was that should Dr. Jakosky develop anything, services would be made available to the Union Oil Company at a cost figure, which has been the case.

Q. Do I understand that last part of your answer to mean that the Echo-Meter has furnished the fluid level and pressure density, and production capacity information to the Union Oil Company at a reduced rate.

A. Qualifying, if I may, your question slightly, they furnish fluid level information. I am not familiar with whether one can group it all, or not, but their services have been at a cost plus 10% basis to the Union Oil Company.

Q. Does the Halliburton Oil Well Cementing Company continue to furnish the fluid level service or information to the Union Oil Company at a reduced rate? A. I understand they do.

Q. Do you know how that rate compares with the charges made by the Depthograph Company for similar service? A. No, I'm afraid I don't.

Q. You don't know whether it is higher or lower?

[524]

A. I presume that it is lower.

Q. In this conversation that you say took place between you and Mr. Rubel relative to Mr. Jakosky,

(Testimony of Howard C. Pyle.)

and what he was proposing to do, was the Depthograph Company and the activity of the Depthograph Company mentioned?

A. I don't recall that it was.

Q. You were familiar with the Depthograph apparatus and methods at that time? A. Yes.

Q. You testified that there were other methods besides this fluid level method of obtaining bottom hole pressure, such as the depth pressure recorder. Is it possible to use the depth pressure recorder to obtain your bottom hole pressure in an oil well that has a pump in it and the pump is operating, without first taking out the pumping apparatus, or at least the sucker rods and pump, in order to put the depth pressure recorder into the well?

A. Will you state the first part of the question?

The Court: I think you had better reframe it. What he wants to know is whether or not you can lower a depth pressure recorder in a well that has a pump in it. Isn't that right?

Mr. Mattingly: That is correct.

A. You can't, no. Now wait; I will qualify that by saying, yes. [525]

The Court: To the bottom of the hole?

A. Yes, and it is currently being done.

Q. To the bottom of the hole? A. Yes.

Q. While the pump is in it? A. Yes, sir.

Q. Without removing the pump?

A. Yes, sir. We are doing that in Mount Poso at the present time.

(Testimony of Howard C. Pyle.)

Mr. Mattingly: Q. Those are relatively shallow wells, are they not?

A. Yes. I think the depth is approximately 2000 or 2200 feet.

Q. The depth pressure recorder, is that lowered in the annular space between the tubing?

A. Yes.

Q. That is possible in a shallow well but it is not possible in a deep well, is it?

A. It has never been done to my knowledge in a deep well. I rather believe it has been used in deeper wells than 2200, but I am familiar with the work at Mount Poso.

Q. That has been done very recently?

A. Yes, it has been within the last two years.

The Court: That is the same size hole all the way down? [526]

A. Yes, in some cases, and in some cases the hole is reduced near the bottom.

Q. And cemented off?

A. The reduced pipe is merely hung in there. The larger pipe is cemented. [527]

ALBERT C. RUBEL,

called as a witness on behalf of the defendant, testified as follows:

My address is Union Oil Building, Tucker 2711, in Los Angeles. I am vice-president of the Union Oil Company of California, in charge of explora-

(Testimony of Albert C. Rubel.)

tion, production and development. I have been with the Union Oil Company approximately 20 years.

Mr. Babcock: Q. Are you familiar with the work done by the Union Oil Company in 1927 and 1928 relating to the use of sound signals to determine the level of fluids in oil wells?

A. Yes, sir.

Q. Will you state in a general way what took place in that connection at that time?

A. Along about 1927, in the Dominguez field we became interested in determining fluid levels in the annulus of pumping wells, and appealed to the research department of our company for some help, and was assigned a research man; I believe it was Dr. Wolcott; I believe that was the name. He came out and worked out with us an experimental machine for determining fluid level by means of firing a shot and making a sound at the casing-head, determining the time that it took for that sound to go down to the fluid level and be reflected and then recording that on a moving film by means of a mirror [528] and beam of light. Such an apparatus was actually built. It was used.

Q. Were any records made by the Union Oil Company at that time? A. Yes.

Mr. Mattingly: Your Honor, I object to questions being asked of this witness, and answers that he has given, unless it is first brought out that he has personal knowledge of what was done.

(Testimony of Albert C. Rubel.)

Mr. Babcock: Q. Do you have personal knowledge of what was done? A. I do.

Q. Did you take any part in the use of the apparatus, or anything of that sort?

A. Yes, I did.

Mr. Babcock: Q. I hand the witness certain documents which have been marked for identification Defendant's Exhibit P, P-1 and P-2, P-2 being a letter of four pages, and ask you if you can identify those documents. These happen to be photostats.

A. I have seen the document that appears to be the same as this; some correspondents about that time. This is on Union Oil Company stationery, and I assume it is the same thing.

Q. Are you referring to all these documents?

A. No, just this letter. [529]

Q. The letter is P-2?

A. I can only say as to this letter, P-1, that I saw the patent applications and various drawings and so forth, accompanying that at that time. Whether this is the same thing or not I would be unable to say, but I know there was such a document prepared at that time.

The Court: Patent applications for what?

A. For this device I described.

Mr. Babcock: Q. Am I to understand that the Union Oil Company did apply for a patent?

A. The Union Oil Company, through Dr. Wolcott, who was a member of the research department, applied for the patent at that time, yes, sir.

(Testimony of Albert C. Rubel.)

Mr. Mattingly: Q. Did you see the patent applications that were prepared and signed by Dr. Wolcott?

A. Yes, sir, I did. May I correct that statement. I saw the patent applications, and I do not know whether they were filed. I think I said patent applications were filed. I saw patent applications and I could not say whether they were filed or not.

Q. This document marked Defendant's Exhibit P-1 appears to be signed by Mr. Wolcott. I don't know his first name. What is that? Edson? [530]

A. I don't recall his name.

Q. It is dated May 16, 1927, and contains this statement: "Tests have been made at Dominguez during the past two weeks. On Tuesday, May 10, 1927, the echo could be heard very distinctly, using a telephone transmitter as microphone, one stage of amplification and a radio head-set as receiver. The sound was made by shooting a pistol across the top of the casing and also by striking metal against metal at the top of the casing. In the latter case the echo was very distinct."

Do you have any knowledge of what is referred to there? A. Yes, I do.

The Court: Does that refresh your recollection?

A. Yes, sir, it does. I accompanied Dr. Wolcott, I believe, in all the experiments that were conducted at the well. The preliminary tests were made, as indicated by that statement, by an amplifying device and head sets. The first experiments

(Testimony of Albert C. Rubel.)

were made by taking two pieces of metal and striking them together, and later I brought my pistol, which was a .22 caliber Colt Woodsman, and fired it, and later brought a .45 caliber six-shooter, and fired it across the casinghead, and I was present and heard the echoes and saw the entire manipulation.

The Court: You heard the echoes through the microphone, or you heard them—— [531]

A. Through the earphones, your Honor. That is what we did.

The Court: You heard the deep echo?

A. We heard echoes from the shot. I don't recall that we had any success at all by striking the metal together, but with the shot we could hear a number of different echoes coming from the well after the shot was gred. This experiment occurred in an idle well that had tubing hanging in it. And we were interested in the fluid level in the annulus between the tubing and the casing. It wasn't just an open well.

Mr. Babcock: Q. Does the drawing marked Defendant's Exhibit P, which is dated April 6, 1928, refresh your recollection as to the apparatus that was used by the Union Oil Company during 1927 or 1928?

A. Well, I would say diagrammatically that it corresponds roughly to my recollection of the apparatus that we subsequently put together to try to record these echoes.

Q. What do you mean by "subsequently"?

(Testimony of Albert C. Rubel.)

A. Well, after the preliminary work had been done with the amplifying device and the headphones, Dr. Wolcott devised a recording device for recording the sound waves of the return.

Q. Can you describe the recorder illustrated on this Exhibit P?

A. I think I can, generally. As I recall it was a mirror [532] attached to the diaphragm, which was again attached to the amplifying device. That mirror had a source of light which impinged on it and then the reflected beam was directed to an perture across which a 16-millimeter moving picture camera film was drawn by the mechanism of a camera. We used an old camera, as a matter of fact, for that purpose. The vibrations of the diaphragm would cause an oscillation of the mirror which in turn would cause an oscillation of the light beam, and that oscillation of the light beam recorded on the film the magnitude of the oscillation, being in proportion to the energy of the vibration. And the movement of the film, of course, stretched that out into a sine curve, and the magnitude, then, of the vibrations that came back were recorded on this film. That is the way the record was made. It was a crude device. The audio amplification unit was taken from a radio. As I say, the recording device was a 16-millimeter camera, and the mirror and light source were made separately, and was all enclosed in a ply-wood box.

(Testimony of Albert C. Rubel.)

Q. Do you know what the device indicated at 11 on the drawing is?

Mr. Babcock: That No. 11, your Honor, appears right on the device.

A. I wouldn't know from that drawing, but I would assume that there would be a recording device there in the form of a [533] microphone. That is what we used at the casinghead.

Q. What is the device indicated by the numeral 6?

A. I presume that indicates the source of the sound. At that time we were experimenting, as I said, with a number of different sources of sound. We used this metal striking together, we used two calibers of pistol shots. As I recall, we used a string of a musical instrument, a mandolin or guitar, and we stretched that to get different amplitudes of sound. And then later Dr. Wolcott devised an oscillating tube as a source of sound. Whether that was ever used in the well or not I do not recall.

Cross Examination

By Mr. Mattingly:

Q. I believe you stated that the work that you testified was done in 1927 or 1928. When was that work actually done?

A. I don't recall the exact dates. It was some time between the middle of 1927 and the latter part of 1928. That is as close as I can fix it from memory.

Q. The apparatus that you have described as

(Testimony of Albert C. Rubel.)

including an old motion picture camera and a light and a mirror, that was actually constructed, was it? A. Yes, sir.

Q. That was constructed as early at least as 1928? [534]

A. It was constructed earlier than the end of 1928. That is about as close as I can come to it. I have to fix this date by reference to other things. I left the Dominguez field in the early part of 1929, and all this work occurred prior to that time, so I know it came in that general period, but I can't fix the date any closer than that from my own recollection.

Q. What was done with this apparatus that you say was completed after 1928?

A. I do not know what disposition was made of it.

Q. So far as you know, the apparatus was not used subsequently to that time, is that correct?

A. It was not used on any Union Oil property subsequent to 1928, to my knowledge.

The Court: Why not?

A. The work was discontinued, your Honor, about that time, and there was no further attempt made to develop it.

The Court: The work? You mean the work of endeavoring to find the fluid level?

A. Yes, sir. It was about that time that the big oil boom started. And the Santa Fe Springs were deep drilling, and we were very much occu-

(Testimony of Albert C. Rubel.)

pied with other things, so we discontinued the work. [535]

Mr. Mattingly: Q. Isn't it true that the next work which was done by the Union Oil Company, in connection with any sound apparatus for finding fluid levels, was subsequent to 1936; in fact, in the middle or last part of 1937?

A. Well, again, I would be unable to fix a date, but it was some considerable time after that and probably about in that period. I recall the work that we did, but I don't recall the date. [536]

Mr. Graham: The defendant offers in evidence a certified copy of the file wrapper which resulted in patent No. 2,156,519, which is the first patent in suit, as Defendant's Exhibit T.

[Printer's Note: Defendant's Exhibit T is set out in full in the Book of Exhibits.]

We offer in evidence a certified copy of the file wrapper of the application which resulted in the Lehr and Wyatt patent No. 2,047,974, as Defendant's Exhibit U.

[Printer's Note: Defendant's Exhibit U is set out in full in the Book of Exhibits.]

Mr. Mattingly: Your Honor, I object to the entry of the file wrapper of the Lehr and Wyatt patent. That is not a patent in suit, and the proceedings which went on in the Patent Office in connection with that patent I do not believe are material to any issue in this case.

The Court: Why isn't it material? You allege

(Testimony of Albert C. Rubel.)

in your original patent that it was an improvement on the Wyatt and Lehr. How am I going to know that it was an improvement unless I know what the Wyatt and Lehr patent is?

Mr. Mattingly: The Wyatt and Lehr patent is in evidence. My point is, I don't feel that the file wrapper is material to the case.

The Court: Objection overruled.

Mr. Graham: We offer in evidence the file wrapper, serial No. 164,534, which has already been offered for identification as Defendant's Exhibit L.

[Printer's Note: Defendant's Exhibit L is set out in full in the Book of Exhibits.] [537]

CRANFORD P. WALKER

recalled by the defendant.

Mr. Babcock: If the Court please, I am calling this witness under Rule 43 (b) of the Federal Rules of Civil Procedure. Your Honor, when we took Mr. Walker's deposition, I asked him certain questions about the date when the exact method of patent 2,209,944 was put in public use, and Counsel has agreed to stipulate that the exact method of that patent went into public use beginning on March 6, 1937, so I will not ask the witness any more questions about that.

Mr. Mattingly: So stipulated.

Mr. Babcock: Q. Mr. Walker, you have testified, I believe, that the first time you saw an apparatus for determining the level of fluid in wells, by

(Testimony of Cranford P. Walker.)

sonic methods, was in the Fall of 1935 when you saw Mr. Lehr demonstrate the apparatus to you?

A. Yes, that is correct.

Q. Do you know when you first saw the Wyatt and Lehr patent that we have been talking about in this suit?

A. It was soon after it was issued in 1936, I believe.

Q. Did you see the application before the patent had been issued to Wyatt and Lehr, the Wyatt and Lehr application?

A. Yes, I had seen the application.

Q. When did you first see that?

A. I haven't the slightest idea. My records might show when I was permitted to see it, but I haven't any idea; but it [538] was some time after, and quite a little while after I started work on this problem actively.

Q. Can you fix the date by reference to when you first saw this apparatus demonstrated?

A. I would say it was—my guess would be that it was several months after that. I have tried to recall that date, but I can't, and I have no way of fixing it. [539]

Q. The Wyatt and Lehr patent issued July 21, 1936. At some time or other, in your work on the Depthograph, you thought of the idea of putting a filter in an amplifier in a recording system, did you not, an electrical filter in an amplifier of a recording system for recording echoes from a well, in a system such as we have been dealing with here?

(Testimony of Cranford P. Walker.)

A. The amplifier that I used in making the re ords that have been submitted in evidence had filter on it, a tone control, it is called in the ordinar radio outfit. This was used, I understand it, fo recording heart beats and had a filter on it which used in my experiments, but it did not have muc effect.

Q. What date are you referring to?

A. I am referring to experiments in the ear part of November.

Q. What year?

A. 1935; November 13th to along towards th latter part of the month.

Q. That apparatus, was that an apparatus tha had a microphone and an oscillograph in this record ing circuit with the amplifier?

A. That is correct.

Q. That filter was a low pass, a low frequenc filter; it was not a resonant tuned circuit, was it

A. I do not know, Mr. Babcock, just what typ of filter [540] it was.

Q. Was it the type of filter that is shown an described in your patent application, now offere as defendant's Exhibit L.

A. I have just testified that I did not know wha type it was. I did not make a very close examina tion of it, so I therefore can't make any comparison between the two.

Q. When did you first conceive of the idea o using a filter in an amplifier circuit in a recordin system which has a microphone recorder as shown

(Testimony of Cranford P. Walker.)

in figure 5 of the drawing of application serial No. 164,534, offered as defendant's Exhibit L?

A. To the best of my knowledge that was about the time that I started experimenting with accoustical tuning, which was during the early part of 1937.

The Court: When you say "experimenting with accoustical tuning", you mean mechanical tuning?

A. Mechanical tuning, that's right, your Honor.

Q. Mr. Walker, in these Depthograph and Echo-Meter operations do you regard the shooting of a gun as the full equivalent of a pressure impulse chamber to initiate the sound or wave to be reflected?

A. They both produced a pressure wave, and the return [541] echo is almost identical with the two methods in wave form, I would say.

Q. Answer the question please, sir.

A. Your statement "full equivalent"—I would not like to say "yes", worded that way. To all practical purposes I would say "yes", the two are the same. Using a pressure impulse has some advantages; it is a little more flexible; that is why I would like to give a conditional answer. They are not exactly the same, but to all practical purposes they are the same. [542]

CRANFORD P. WALKER

recalled as a witness on behalf of plaintiffs, in rebuttal, testified as follows:

(Testimony of Cranford P. Walker.)

Direct Examination

Mr. Mattingly: Q. Mr. Walker, during the taking of your direct testimony you mentioned the fact that a certain application for patent, which is in evidence now as Defendant's Exhibit A, was abandoned. Will you explain to the court the circumstances under which you abandoned that application? That, for your information, is the application for which an application was filed which resulted in patent 2,209,944.

The Court: Didn't he go into this before?

Mr. Mattingly: This is the testimony that your Honor interrupted and said that it was proper rebuttal testimony. This being rebuttal, I would like to get this testimony in.

The Court: All right.

A. Before patent 2,209,944 was issued, or ready to be issued, two other patents in suit here were issued, namely, 2,156,519 and 2,161,733, which was the reissue, and 21,383, and we notified our competitor at that time, Mr. J. J. Jakosky, who was head of the International Geophysics, Incorporated, of his infringement of those two patents. Mr. Jakosky expressed a desire to be licensed to operate under those two patents, and negotiations with him began very soon after these patents were issued, and I believe that was during the middle of 1939. [543]

Mr. Graham: Your Honor, I fail to see the relevancy of talking to Mr. Jakosky, or what Mr. Jakosky wanted, and what they agreed to do with filing these applications.

(Testimony of Cranford P. Walker.)

The Court: I think the evidence is admissible, anyhow.

Mr. Graham: Your Honor, may I say a word on that?

The Court: Yes.

Mr. Graham: As I understand from the evidence as it is going now, Counsel has made it a point that the Commissioner of Patents has discretion; he examines the file and after he examines the file he makes up his mind. Now, may I ask Counsel if any of this testimony he is going to get from this witness on that point was before the Commissioner of Patents when he so-called made up his mind?

Mr. Mattingly: It was not.

Mr. Graham: Then how is it before this Court?

The Court: It seems to me that the evidence which would be adduced by the answer to the question, as indicated by the question, and the subject matter to be covered by it, whether or not it is admissible under your present theory, is admissible by way of estoppel against the defendants.

Mr. Graham: Against the defendants?

The Court: Hasn't there been some evidence here that Jakosky was the predecessor in interest who made or who devised these machines?

Mr. Graham: He had nothing to do with these applications, [544] your Honor.

The Court: No.

Mr. Graham: No connection with them.

The Court: I am not speaking of that, at all. But the thought which occurred to me is that if

(Testimony of Cranford P. Walker.)

you are getting the benefit of your agent, and assuming that Jakosky was your agent or your predecessor in interest, you cannot be held to complain now if he induced the plaintiff here to act against the plaintiffs' interest.

Mr. Graham: I don't get it, your Honor.

The Court: In other words, assuming that your contention of the law is correct, then the question arises as to whether or not you were estopped from asserting that.

Mr. Graham: Well, I haven't seen any evidence here that could even remotely be connected with that, your Honor.

The Court: I don't know whether it was testified on the witness stand, but I read from the deposition, I guess I shouldn't have read the deposition. But I recall that Mr. Jakosky was the man who built the Echometer——

Mr. Graham: Originally, yes.

Mr. Graham: That is correct.

The Court: And that the present defendant in this case took over this equipment and his business, the exclusive right to use [545] that equipment.

Mr. Graham: That is correct.

The Court: Now, whatever you have got depends upon Jakosky, doesn't it? I mean, if Jakosky hadn't produced it or made it, you wouldn't have it. Whatever you have got comes from Jakosky. Now, if Jakosky, the man upon whom you rely, induced the plaintiff to act against his interest by unfair means or unlawful means or fradulent

(Testimony of Cranford P. Walker.)

meant, or any means short of those which would stop Jakosky from complaining of the plaintiffs' abandonment and filing a renewal, then it seems to me that it would be admissible as against you.

Mr. Graham: Well, it certainly will, and I have no objection to counsel asking any questions on that, because there is nothing of that kind in the case, your Honor. You don't claim there is, do you, Mr. Mattingly?

Mr. Mattingly: Let's see what the evidence is.

Mr. Graham: Do you plead any estoppel of that kind?

Mr. Mattingly: I have not pleaded any estoppel of your right to raise this defense.

Mr. Graham: Well, for the purposes of understanding the testimony, are you making a statement that you are claiming, under any circumstances whatever, that Mr. Jakosky has influenced this witness in connection with abandoning the original application of 2,209,944 or filing a new application?

Mr. Mattingly: Yes, I feel that Mr. Jakosky did, by his [546] acts and statements, induce this witness to take the course of procedure which he did.

Mr. Graham: All right.

Mr. Mattingly: Q. As I recall, Mr. Walker, I was asking you to state the circumstances which led you to abandon application Serial No. 270,865, Defendant's Exhibit A, and file a continuing application, which finally resulted in patent 2,209,944——

Mr. Mattingly: Shall I go on and recite what I remember of the witness' answer up to the time——

(Testimony of Cranford P. Walker.)

The Court: Well, you ask your questions.

A. If I remember correctly I stated that negotiations had started between ourselves and Mr. Jakosky with a view of granting him a license under the two previously issued patents, the numbers of which I have already given.

The Court: Which numbers? Tell us again. The Wyatt and Lehr——

A. The first two patents that were issued to me, your Honor, namely, 2,156,519 and 2,161,733, reissued as 21,383.

The Court: Well, had 21,383 been issued when these conversations occurred with Jakosky?

A. No, they hadn't. During those negotiations Mr. Jakosky severely criticized the way in which the claims had been drawn and the patents in general, and much of it I thought was, at least I hoped was to frighten me into a favorable contract with him; but, nevertheless, I lost considerable sleep over his criticisms of the claims. During that time this application, which [547] resulted in 2,209,944 was pending.

Mr. Mattingly: Q. Will you give the serial number of that application? Is that 270,865?

A. That is my understanding. 270,865 was the application number at that time. Previously I had assumed that if an idea were completely disclosed and a claim was drawn covering, in a general way, what the idea was, that the subject was covered pretty thoroughly, and somebody else got up some little different way of doing something it wouldn't

(Testimony of Cranford P. Walker.)

make any appreciable difference as long as the basic idea was the same. But his criticisms were not in agreement with that idea of mine, so I began worrying about this other application. But in the meantime the patent was allowed, and without any authorization from me the fee was paid, without my knowing it, and I had no way of making any changes. After talking with Mr. Jakosky I wanted to consult other patent attorneys on the subject, and I did subsequently consult two other firms regarding those claims.

Q. Will you tell us who the firms were?

A. Mr. Robert Smith, an independent attorney operating independently, and Mr. Leonard Lyon, of Lyon and Lyon.

Q. What did you do when you found the patent application had been allowed and the final fee had been paid?

A. I got very much excited about it, and was advised that one way to have a thorough reconsideration of the application—incidentally, the application had a couple of claims which were [548] not properly worded and the meaning, according to my interpretation, was changed by the way they were worded, from what was meant. Those corrections were subsequently made. The application was abandoned and immediately the continuation was filed——

A. As I was saying, the other two patents had taken so long to get through the Patent Office, and this division was filed only in April, 1939, and I had

(Testimony of Cranford P. Walker.)

not expected it to issue as a patent for a considerable time after it actually did issue, and it was very much of a surprise to me when it had been allowed and the final fee paid.

The Court: Now, I understand that Jakosky talked to you between May 6, 1939, and September 14, 1939?

A. That is correct, your Honor. The negotiations with Mr. Jakosky began early in July, if I remember correctly, because that followed very soon after we notified him, which was July 6th, I believe, 1939.

Q. Up to that time you had only had one patent issued, hadn't you?

A. No, your Honor, there had been two patents issued.

Q. What was the second? There was 2,156,519—2,161,733?

A. That is correct.

Q. All right, go ahead.

Mr. Mattingly: Q. I believe you said you subsequently conferred with two other attorneys, Mr. Smith and Mr. Leonard Lyon?

A. Yes, sir. [549]

Q. What was the result of your consultation with those attorneys?

A. Two claims, if I remember correctly, were added, and before those consultations these corrections had been made. They, in fact, had been made in this renewal or continuation which occurred—well, I am not an attorney; I haven't the informa-

(Testimony of Cranford P. Walker.)

tion anyway. As soon as it was abandoned and renewed, these corrections, and probably some more changes were included; then we began consulting other attorneys.

Q. And these additional claims that you have referred to were put into this continuing application which did result in patent No. 2,209,944?

A. That is correct.

The Court: Where did these negotiations take place with Jakosky?

A. The first meeting was in Mr. Mattingly's office, and those present were Mr. Knight, according to what I understood at that time, was Mr. Jakosky's attorney, Mr. Mattingly, Mr. Robert Miller, and myself. That is correct, isn't it?

Mr. Mattingly: I think that is correct.

The Court: Q. Who said what to who?

A. Mr. Jakosky did most of the talking, I believe.

Q. What did he say?

A. He criticised the details of the specifications.

Q. Criticising is a conclusion. I am supposed to [550] decide whether or not he criticised. Tell me what he said.

A. He said we had not included certain things in some of these specifications which should have been included, and it looked like we were going to work together and work out some sort of a cross-license arrangement, and he made some constructive criticisms, I believe, as to what should be done, but

(Testimony of Cranford P. Walker.)

as to the details of the criticism, I don't recall, your Honor.

Q. What did you say?

A. As little as possible.

Q. Did you indicate to him by your attitude or your language that he could expect a licensing arrangement?

A. I think we did. Only one thing stands out in my mind. He said, "You should have applied for electric tuning in this thing. Why didn't you apply for electrical tuning? You have applied for acoustical tuning." I could hardly keep from smiling, because I had already done it.

Q. You did not tell him you had already done it?

A. No.

Q. You did not? A. No.

Q. Did you rely upon what Mr. Jakosky said?

A. He was considered, some say, as quite a patent authority, and others say as a patent shark. I don't know which is the correct description; but it gave me cause to worry about the way the patent claims had been drawn. In answering your question as to [551] where the meeting took place, several meetings took place in Mr. Robert Miller's office.

Q. Who was he?

A. My partner, or one of my partners, with Mr. Jakosky, Mr. Miller and I, and sometimes some one else in Mr. Jakosky's office. I don't recall just who else was there. I think the last meeting we had Mr. Philip Subkow was with us, and that was in,

(Testimony of Cranford P. Walker.)

I think, Mr. Subkow's office. I think it was in February, 1940.

Mr. Mattingly: Q. I show you a record, and ask you if that is a record which you made at the well in Kansas with a gun shot initiated by the defendant's apparatus?

A. That is; that is correct.

The Court: You want that marked, I suppose, as Plaintiffs' 33. That is a record by the plaintiff of the defendant's shot in Kansas?

Mr. Mattingly: I will offer that record in evidence your Honor.

The Court: It may be admitted.

The Clerk: Plaintiffs' Exhibit 33 in evidence.

The Court: I suppose you have got 34 now, as a record in the same well of Plaintiffs' pressure impulse?

Mr. Mattingly: That is correct, your Honor, and our record strip—is that the record strip that was made at the same well from an impulse which was initiated by the Depthograph pressure chamber?

[552]

A. It is.

Mr. Mattingly: I offer that record in evidence as Plaintiffs' Exhibit No. 34.

The Court: This will be Plaintiffs' Exhibit No. 34.

Cross Examination

Mr. Graham: Q. These talks with Dr. Jakosky, when were they, Mr. Walker?

A. They extended over a period, if I remember

(Testimony of Cranford P. Walker.)

it correctly, shortly after we notified him that he was infringing the two issued patents until, I believe the last meeting, as I have stated previously, was in February, 1940; from about the middle of 1939 to probably the early part of 1940.

Q. When was it he talked to you and you got so agitated about the claims?

A. That was brought on by the payment of this final fee by Mr. Jones on this patent application.

Q. Did you not at that time know all about, or long prior to that time, know just what Mr. Jakosky was doing?

A. I knew something about what he was doing.

Q. You knew enough about it in February, 1939, to file an affidavit in the patent office claiming that in your opinion what he was doing constituted infringement of the claims in your patent application, didn't you? A. Yes. [553]

Q. Now, referring to your deposition that was taken in this case on February 28, 1942, you were interrogated by Mr. Babcock as to the reasons why you abandoned this application, and on page 95 of that deposition Mr. Babcock stated:

"I am talking about the prosecution, about whether you abandoned that application. The witness has testified that he collaborated with Mr. Mattingly in the prosecution; the file history contains a document which purports to be his statement, signed by him, expressly abandoning the application. I want to know if he recalls discussing it with you, whether he ought to abandon that application.

(Testimony of Cranford P. Walker.)

"A. Yes, there was some discussion about going through some patent office formality, which I wasn't familiar with, which might have involved a temporary abandonment of this application.

"Q. By that time, by the date you signed that abandonment there,—what is that date, by the way—September 22, 1939, you knew all about what Jakosky and the International Geophysics, Inc. were doing, did you not?

"A. No, I can't say that I did.

"Q. You knew nothing about what they were doing?

"A. I knew very little about what they were doing.

"Q. Mr. Walker, in another application you filed an affidavit that you knew all about what they were doing, and that they were infringing this method and all your methods; did you not file it right in the patent office six months before that time? [554]

"A. I doubt very much that I stated that I knew all about what they were doing; that of course would not have been a true statement.

"Q. Well, did that have anything to do with abandoning this application,—what they were doing, what Jakosky and his group were doing?

"A. Nothing that I know of.

"Q. Why did you abandon that application?

"A. If I remember correctly, it was to reword some of the claims.

"Q. Do you recall whether you — let me say first,—where were you, do you know, when you

(Testimony of Cranford P. Walker.)

signed this abandonment; can you tell from that paper, the address of it?

"A. No; I don't recall."

Do you recall of so testifying, Mr. Walker?

A. Yes.

The Court: What page is that on?

Mr. Graham: Q. And on page 100 of that same deposition:

"Q. You have no recollection of being in Mr. Mattingly's office, and on the same day abandoning application, Serial No. 270,865 and signing the oath for the application which has matured into patent 2,209,944?

"A. I can't say at this time when or where the others were signed—

"Q. Well, you have no recollection of discussing that with [555] Mr. Mattingly, or anything of the kind?

"A. Discussing the signing of papers?

"Q. Yes, abandoning the first, and filing the second?

"A. Yes, that was discussed.

"Q. Don't you know why you wanted to abandon the first and file the second?

"A. Well, I would say it was probably to make some corrections.

"Q. It is a cinch you would not just want to spend another thirty dollars, once you had this first all allowed here; why did you want to pay another thirty dollars and file a new one on the same thing?

(Testimony of Cranford P. Walker.)

"Mr. Mattingly: Is that a question?

"Mr. Babcock: Yes.

"A. I am afraid you will have to ask my attorney about that.

"Q. You haven't any idea, he didn't tell you why you should give him another fee and pay another thirty dollars to the Patent Office?

"A. I suppose he has to live.

"Q. You have no recollection at all, is that correct?

"A. As to the details of why it was changed, that is correct. It was for the purpose of correcting mistakes, as I recall.

"Q. But you are sure it had nothing to do with repatenting it so that you could cover what the International Geophysics were doing, or what Jakosky was doing?

"A. I don't know for sure just what he was doing, in detail." [556]

Q. Is that a correct statement of your testimony at that time, Mr. Walker?

A. I think it is, except you skipped some of it.

Q. Now, you have spoken about calling in other attorneys and conferring. How long was it after you abandoned your application and filed a new application that you had this conference with other attorneys? Wasn't it six months?

A. I don't think so. It was some time after that occured.

Mr. Graham: Well, that is all right. We will

(Testimony of Cranford P. Walker.)

show that from the file histories that are in evidence at this time.

Q. Do you recall in this so-called continued application you permitted that to become allowed, then after it was allowed added some claims in July, 1940?

Mr. Mattingly: I think the file history of that application speaks for itself. This witness can't add anything to it or detract anything from it.

The Court: Yes, it does, but he has a right to ask him whether or not he recalls it. Do you recall it? A. I believe I do, your Honor.

Mr. Graham: Q. And do you recall whether or not they were the only claims that were added to that application?

A. My memory is that two claims were added. The records will show, but that is my memory.

Mr. Mattingly: The plaintiff rests.

Mr. Graham: The defendant rests, your Honor.

[557]

The following colloquy occurred at the oral argument:

Mr. Graham: There is one thing, your Honor, that I might say right here. It has been rather indefinite. I don't know what is in your Honor's mind, but it has not been clear at all just what the plaintiff relied on, and does rely on, as to infringement of that first patent, (2,156,519) in this respect: He apparently depends upon the law of equivalency. Whether that is in your Honor's mind or not, I don't know.

The Court: Yes, it is.

Mr. Graham: I would like a statement from the plaintiff, so that we can talk on the subject directly, as to what part of defendant's apparatus he relies on as being the equivalent of what part of plaintiffs' apparatus.

The Court: Here is what is in my mind. I think it is the same means relating to the pressure impulse; the pressure responsive device, accoustical tuning, the introduction of the impulse in the responsive device, and the accoustical tuning, and there is one other—and the recorder, used together—as I understand, no claim is made that the recorder is new, but they are all used together. I think that everything that the defendant does here is the equivalent of what the plaintiff does, or is an imitation.

Mr. Graham: In the opening statement I asked Mr. Mattingly, if we omitted the filter from our apparatus, did [558] he claim infringement, and he said, no.

The Court: Yes; I remember that question and that answer. I wondered what its significance was at the time, and I don't know that it is clear to me yet.

Mr. Graham: Your Honor, here is the point: With that statement, we have proceeded on the theory that the statement should be binding on the plaintiff; that is, if we leave the filter out of our apparatus, then we don't infringe. The testimony is that we don't use it except on some occasions;

we don't use it all the time, and we can do without it.

The Court: Yes, the testimony is very clear. But you don't count tubing collars when you leave the filter out.

Mr. Graham: Certainly, we do.

The Court: When you leave the filter out?

Mr. Graham: Yes. If that is true, then we don't infringe if we leave the filter out. I want counsel to say what part of plaintiff's patent he claims the filter to be an equivalent of.

Mr. Mattingly: I consider, in connection with the filter, together with the amplifier, that the filter works in such manner as to cause your tubing collar echoes to stand out above disturbances and noises, and that, we consider is the equivalent of our accoustical tuning pipe, which we use between the diaphragm and well connection for the purpose of doing exactly the same thing, namely, making the tubing [559] collar echoes stand out above the disturbances and noises.

Mr. Graham: That is a clear statement; and I understand it to be that with the filter left out we do not infringe, but with the filter in, then the filter in combination with the amplifier is the equivalent of your acoustical resonance chamber, which is the pipe adjustable in length.

The Court: Tuned acoustical resonator?

Mr. Mattingly: I would like to correct one impression; that is, in answer to Mr. Graham's question, whether or not if the defendant left the filter

out of its system, would that infringe? May I ask if that is, that it would not infringe unless they used something else in their system which did accomplish the result of tuning and making these collars more active?

The Court: What would that be?

Mr. Mattingly: You can use a particular kind of amplifier, for example—I don't know what the ingenuity of the defendant might devise to take its place—that would cause these collars to be accented above the noise, and other things, which both plaintiff and defendant in actual practice have found to interfere with the clear registration of tubing collar echoes.

Mr. Graham: We are dealing with whatever they are using in the defendant's device before the court. We are not dealing with conjectures and possibilities. It is this thing [560] that is here. Consequently the question is: If we were enjoined on that patent, and we left the filter out, then we are free of the patent, as I understand your statement. Are you challenging that?

Mr. Mattingly: If you left the filter out and used the same amplifier you are now using. If all you did with your device was to leave the filter out, then I do not believe you infringe the claims of the patent by doing that.

The Court: 2,156,519?

Mr. Mattingly: Yes. I think one of the difficulties perhaps Mr. Graham is laboring under—I know it has given us difficulty in this case—is to

get a true picture of exactly what the word "filter" covers. In testifying Dr. Mackeown consistently testified and considered the filter circuit as an independent device, something which was independent of the amplifier, and he treated the two as two separate items, and yet, in his cross examination he admitted that the filter in combination with the amplifier, that is, the filter-amplifier combination, was the thing which constituted the accenting of the tubing collar echoes.

Mr. Babcock: Your Honor, we made several tests. We took the plaintiff out, and showed him. We made records with filters and tests without the filter. They are in evidence. I don't know just what the exhibits are, but you can hardly tell them apart; the one out on the Callender well, out at [561] Dominguez.

Mr. Mattingly: You can count collars on one as well as on the other. Each little wiggle is a different shape, and the filter makes them a little easier to count that way. It takes out the noise, and other things.

The Court: As I remember those exhibits, the one where the filter was not used there was considerable violent action in the recording device, so it was almost impossible to read it until you got down in the well further. With the filter on it you could read it at once.

It looks to me if when the defendant doesn't use the tuning device, then it doesn't infringe 2,156,519.

Mr. Mattingly: That is correct.

The Court: You say you don't use that?

Mr. Graham: We don't say that. In most of the cases we don't.

The Court: So far as the plaintiff is concerned, it looks to me that you should waste no further time on the apparatus of 2,156,519 in view of your statement, in other words, that they do not infringe unless they use the filter.

Mr. Mattingly: They do not infringe unless they use the filter, or an equivalent tuning means.

The Court: Or an equivalent tuning means; and on that point, I think your tuning apparatus is an equivalent of their recording device. [562]

Mr. Graham: I want to make a statement. I don't want anything we have said to be construed as an admission on our part, even with the filter, your Honor, that it is an infringement, because we have something to say on that subject.

The Court: The plaintiff does not need to waste any more time on that.

They have said you don't infringe unless you use the equivalent of a tuning device, or the tuning device. They say if you don't do that you don't infringe.

Mr. Graham: We are not going to stop using the filter. I don't admit that that is a tuning device, but I say we are not going to stop using that filter unless the court enjoins us against using a filter.

The Court: Inasmuch as the matter of whether it is a pressure impulse or a shot is concerned, if

you don't infringe it doesn't make any difference whether you use a pressure impulse by gas, by a short introduced into the well, or whether you suck the gas out, or blow it out, as long as you don't use the tuning device, or its equivalent, on 2,156,519, isn't that your position?

Mr. Mattingly: That is correct.

Mr. Babcock: Relative to reissue patent 21,383, I have here on this sheet six ways of measuring bottom hole pressure under various conditions. Let me give you a copy of this, your Honor. [563]

(The Court was thereupon given a copy of a paper reading as follows:

"A. Some Ways to Measure Bottom Hole Pressure:

1. Conditions: An open well. Density of fluid known or determined by catching sample and weighing it or the like.
   Procedure: Make a fluid level determination. Multiply height of fluid column by density which gives bottom hole pressure.

2. Conditions: Closed-in well with gas above fluid. Density of fluid known or determined by weighing sample or the like.
   Procedure: Make fluid level determination. Multiply height of fluid column by density of fluid to get pressure on bottom due to fluid. Add pressure due to gas (casing head pressure corrected by Dice's formula or the like.)

3. Conditions: An open well. Density of fluid unknown.
   Procedure: Determine density by measuring pressure at two different fluid levels; then proceed as in (1).

4. Conditions: Closed-in well with gas above fluid. Density of fluid unknown.
   Procedure: Determine density by measuring pressure [564] at two different fluid levels; then proceed as in (2).

5. Conditions: Same as (4).
   Procedure: Increase gas pressure until all the fluid is out of well, so that gas pressure is bottom hole pressure. Measure casing head pressure and apply Dice's formula.

6. Conditions: Same as (4).
   Procedure: Increase gas pressure enough to depress fluid some measurable distance. From this, estimate how much casing head gas pressure would be required to force fluid clear to bottom. Apply Dice's formula to the estimate.

B. Some Ways to Estimate Production Capacity:

1. Compare variations in bottom hole pressure with variations in pumping rates.

2. Compare variations in fluid level with variations in pumping rates."

The Court: Do you have one more for Mr. Mattingly?

Mr. Babcock: Yes. I would like to consider which of these various ways this patent (Reissue 21,383) is really supposed to cover. I can't conceive that it would cover No. 1, where, as I say, you just had, say, a water well; you knew the density of the fluid, and all you did was to find out how much height of fluid you had. I might ask counsel: Is there [565] any contention that that would be infringement of this patent?

Mr. Mattingly: I am not sure that I understand the issue you are setting up.

Mr. Babcock: Here is what we do in Kansas; it is very common to just have an open oil well, no gas coming off, and everybody knows the gravity of the oil being produced; and we go out to the well with this Echo-Meter, and find out the fluid level.

The Court: Just one fluid level?

Mr. Babcock: Just one fluid level. From that the operator, or anybody else, can calculate the bottom hole pressure, because he knows the density of the liquid in the hole.

The Court: That is on the assumption that the oil that is coming out of the hole is the same gravity fluid that is in the annular space?

Mr. Babcock: Yes. The well is making no gas. Just ordinary oil. I can't conceive that that would infringe this patent.

Mr. Mattingly: No, that would not infringe the

patent, because each one of the patent claims in Reissue 21,383 specifies that you must take two fluid levels under two different pressure conditions. If you only take one fluid level, it doesn't infringe those claims.

Mr. Babcock: Referring again to this memorandum, I [566] gather from the discussion I have just had with counsel that it will not be contended that item No. 2 will infringe.

Mr. Mattingly: Where you are making only one fluid level determination, I think that is right.

The Court: No. 3 has two fluid level determinations. He contends there is *there*?

Mr. Babcock: No doubt. Also No. 4. What about No. 5, where you have a closed-in well with gas above the fluid, but you force all the fluid out, and just determine the gas pressure?

Mr. Mattingly: I don't think we have any claim in patent Reissue 21,383 on which that would read.

Mr. Babcock: What about No. 6, where, instead of forcing it clear down you only force it down enough to determine how much gas pressure would be necessary to force it clear down?

Mr. Mattingly: That would be infringement.

The Court: You have to make two fluid level measurements there?

Mr. Mattingly: That's right.

Mr. Babcock: Yes, and then extrapolate. Also on this chart we have two ways of determining the production capacity of a well.

No. 1 would be like Figures 4 and 5 of the reissue

patent, where you determine two bottom hole pressures at two different pumping rates. I presume it will be charged [567] that would be infringement?

Mr. Mattingly: Not unless you go further, and state how you get these two bottom hole pressures. Our claims in patent Reissue 21,383, directed to obtaining production rates, specify that you have to use two fluid levels at one rate of production, and then two fluid levels at a second rate of production, and then make your comparisons. This patent would not be broad enough to cover the use of a pressure recorder which is put in the well, and then the well operated at two different pumping rates. We don't contend our patent covers that.

The Court: Comparing the bottom hole pressure with variations in pumping rate; you concede that wouldn't be an infringement, unless they use more than one fluid level?

Mr. Mattingly: To obtain the bottom hole pressure.

The Court: So any way they can obtain bottom hole pressure, otherwise than by method 1, 2 or 5, no infringement is charged unless it be obtained by at least two fluid level determinations?

Mr. Mattingly: That is correct.

I would like at this time to move that claim 6 of Reissue patent 21,383 be considered as one of the claims in suit in this case. I do not think that any of the defenses which have been asserted here will alter the defense at all by the inclusion of

claim 6 as a part of the suit, because such defenses would be directed [568] against that claim as the balance of the claims. It would not, as I see it, prejudice the defendant's position at this time, if we admit claim 6 is one of the claims in suit.

Mr. Babcock: We don't care, your Honor.

The Court: If you don't care I will grant plaintiffs' motion; plaintiffs' motion to amend the pleadings to conform to the proof.

Mr. Mattingly: That's right.

The Court: So as to include claim 6 of patent 21,383 as being infringed, and included within the request for relief. That is granted.

Mr. Babcock: Your Honor wanted me to discuss the question of renewal.

The Court: 2,209,944 is the renewal patent?

Mr. Babcock: Yes. That defense goes only to 2,209,944.

The Court: I am not impressed with your defense on that so far, even in spite of the very able and overwhelming argument that Mr. Graham put forth; but it seems to me that Section 38 had an entirely different application, a different application in the mind of Congress. I think plaintiffs' position on that is correct, but the entrails of the patent, whether or not it is invention, it does not strike me that 2,209,944 is invention.

In other words, with the repeal of that statute I don't think it affected plaintiffs' right at all, and I think that he, having paid the fee and applied for a renewal, that he was within [569] his rights in

doing so, and abandoning the patent before it was issued.

Plaintiff here had not secured his patent. He applied; he paid his fee, which was to say: Yes, that's what I want. Then he discovered that it was not, and he said: Just a minute, Mr. Government, I don't want that patent. I am going to abandon this by filing a continuation, because there are some things I want to change.—I may be wrong on the law as to that, but that is my present impression. That is what the law permits.

Mr. Babcock: In view of your Honor's statement about patent 2,209,944 I would like to reserve the right to argue it.

The Court: All right.

Mr. Babcock: Not right now, though.

The Court: I have absolute confidence that the plaintiff cannot prove invention on 2,209,944. Have you?

Mr. Babcock: Yes, sir.

The Court: I don't think I am going to have any better understanding of this case than I have right now. In fact, I think if I let it go, as I indicated this noon, I will probably be more at sea than I have been, and with all the skill you gentlemen have you probably have observed the difficulty in keeping me on the track; so I think I am prepared to announce my decision at this time.

On the issues involved, as I see them now, it is a question, regarding 2,156,519 first, as to whether or not the plaintiff's [570] Walker's, claims in suit

are invention and valid, and in that respect I hold they are.

The next question as to 2,156,519 is whether or not the use by the defendant of the filter apparatus in the manner which has been described, and which it has admitted using, is [571] infringement; and as to that I hold it is infringement. That disposes of all of the issues involved in patent 2,156,519, isn't that correct?

Mr. Mattingly: Yes.

The Court: As to 2,209,944, I hold against the defendant's contention advanced to the effect that the patent is void, and not being a proper continuation. I hold in favor of the defendant, and against the plaintiffs' claim, that all of the plaintiffs' claims in that suit are invention, and I hold that they are not patentable, and that the patent is not valid. Consequently the patent, not being valid, the defendant could not have infringed. That disposes of 2,209,944.

As to Reissue 21,383, all of the claims involved in patent Reissue 21,383 can be disposed of under the determination of the two issues, as to whether or not the patent is invention, and as to whether or not it has been infringed. I mean, I do not need to go through claims 1 to 11, for the purpose of this ruling, is that correct, counsel?

Mr. Babcock: I think so.

The Court: All of the claims can be disposed of by a determination of whether or not Reissue 21,383 is invention, and as to whether or not it is

infringed; so I don't need to decide claims 1, 2, 3, 4, and down the line. As I remember the patent, and follow the arguments, we have not analyzed [572] this patent claim for claim, as we did 2,209,944. Is there any reason why I have not stated that correctly?

Mr. Mattingly: I think you may dispose of all the claims of that patent.

The Court: By disposition of those two issues?

Mr. Mattingly: That's right.

The Court: In other words, is there any distinction between those claims?

Mr. Babcock: I don't think so.

The Court. As to Reissue 21,383, therefore, I hold that it covers invention, and that the plaintiffs' patent is valid, and that the things done by the defendant in connection with the ascertainment of bottom hole pressure and the ascertainment of potential production of oil wells are infringement. Now, in that regard I want to modify that, because during the argument it was conceded if they have followed certain methods, it would not infringe.

Mr. Mattingly: That's right.

The Court: I will hold that the defendant infringes by the use of any method which involves the taking of two fluid levels higher in the well than the bottom of the pump. I think that covers it, doesn't it?

Mr. Mattingly: Yes, your Honor.

The Court: And the plaintiff is entitled to an injunction, in accordance with the announced judgment I have just [573] made. The findings of fact

and conclusions of law, and judgment will be prepared and submitted by the parties.

[Endorsed]: Filed June 1, 1943. [574]

District Court of the United States, Southern District of California, Central Division

No. 1655-PH

CRANFORD P. WALKER; and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as DEPTHOGRAPH COMPANY,

Plaintiffs and Cross-Appellants

v.

HALLIBURTON OIL WELL CEMENTING COMPANY,

Defendant and Cross-Appellee

STIPULATION AND ORDER FOR TRANSMISSION OF EXHIBITS TO NINTH CIRCUIT COURT OF APPEALS

It Is Stipulated and Agreed by and between counsel for the respective parties hereto that each and every of the following original exhibits on file in the District Court in the above entitled cause be transmitted to the Ninth Circuit Court of Appeals and that the Clerk of the District Court be authorized so to do:

Plaintiffs' Exhibits 1, 2, 3, 6, 7, 8-A, 8-B, 8-C, 8-D

9, 10, 11, 12, 10-A, 10-B, 10-C, 11-A, 11-B, 11-C, 12-A, 12-B, 12-C, 12-D, 12-E, 13, 14, [676] 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29;

Defendant's Exhibits A, B, C, D, E, F, F-1, G, H, I, J, K-1, K-2, K-3, K-4, K-5, K-8, K-9, L, O-2, O-4, O-5, O-7, O-9, O-13, O-14, Q, R, S, T, U.

HAROLD W. MATTINGLY
ROBERT W. FULWIDER
Attorneys for Plaintiffs and Cross-Appellants
FRANK L. A. GRAHAM
EARL BABCOCK
Attorneys for Defendant and Cross-Appellee

Approved and So Ordered:
PEIRSON M. HALL
United States District Judge

July 7, 1943

[Endorsed]: Filed July 7, 1943. [677]

[Title of District Court and Cause.]

STIPULATION AND ORDER RE INSERTION OF EXCERPTS IN THE RECORD ON APPEAL FILED BY DEFENDANT HEREIN

It Is Stipulated and Agreed by and between the parties to the above entitled cause, by their respective counsel, the Court consenting thereto, that the pages of Statement of Points to be relied upon by Plaintiffs in their appeal, Designation of additional portions of the record by Plaintiffs and Defendant,

Defendants amended Answer and the Reporters Transcript of [678] Testimony and proceedings before the District Court filed with Defendants Designation of Portions of the Record to be added to the portions of the record designated by Plaintiffs may be inserted in the Record on Appeal heretofore filed by Defendant-Appellant, and the Clerk of the District Court is hereby authorized to make such insertions.

HAROLD W. MATTINGLY
ROBERT W. FULWIDER
Attorneys for Plaintiffs and Cross-Appellants
FRANK L. A. GRAHAM
EARL BABCOCK
Attorneys for Defendant and Cross-Appellee

It Is So Ordered:

PEIRSON M. HALL
Judge

July 7th, 1943

[Endorsed]: Filed July 7, 1943. [679]

[Title of District Court and Cause.]

DESIGNATION OF CONTENTS OF RECORD ON APPEAL

Comes Now the Halliburton Oil Well Cementing Company, Defendant-Appellant in the above entitled cause, and designates the following portions of the record, proceedings and evidence to be contained in the record on appeal:

Complaint
Bill of Particulars
Answer (abridged)
Findings of Fact and Conclusions of Law
Decree
Notice of Appeal
Designation of Contents of Record on Appeal
Statement of Points on which Defendant-Appellant Intends to Rely on Appeal [680]
Narrative Statement* of Testimony
The following exhibits:

Plaintiffs' Exhibits

1 Walker patent 2,156,519 in suit
2 Walker patent Reissue 21,383 in suit
6 Echo-Meter folder describing Defendant's Apparatus
7 Echo-Meter advertisement
8-A, 8-B, 8-C, 8-D Echo-Meter Field Data Surf Associates Well—State #1
9 Echo-Meter Field Data on Surf Associates Well—State #1
10, 11, 12 Plaintiffs' Interrogatories and Defendant's Answers thereto (combined and abridged)
10-A Drawing—Plaintiffs' illustration of Defendant's apparatus
10-B Graphs made by Defendant's Echo-Meter on Cities Service Well—Ray B-2

---

*Footnote: In the Narrative Statement, the page numbers of the official reporter's transcript, from which the narration is taken, appear in the side margin.

10-C Graphs made by defendant's Echo-Meter on Phillips Petroleum Co. Well, Kraft #3

11-A Graph made by Defendant's Echo-Meter on Union Oil Co. Well—Stinson #1

11-B Graph made by Defendant's Echo-Meter on Pace Pet. Corp. Well—McMasters B-1

11-C Echo-Meter Field Manual (abridged)

12-A Drawing of Echo-Meter Casinghead Unit [681]

12-B Photograph of Echo-Meter Casinghead Unit

12-C Photograph of parts of Echo-Meter Casinghead Unit

12-D Photograph of Echo-Meter Electrical Recording Instrument

12-E Calibration curve used to calibrate Filter in Defendant's Echo-Meter Recorder

14 Drawing—Plaintiffs' Illustration of Defendant's Apparatus (the drawing of Exhibit 10-A slightly modified)

18 Prior art patent to Lehr and Wyatt, 2,047,974

19 Graph made by Walker at Shell Oil Co. Well Cosbloom No. 1, Nov. 19, 1935, in attempt to operate apparatus like that of Lehr and Wyatt patent

20 Graph made by Walker on Nov. 20, 1935 in attempt to operate apparatus like that of Lehr and Wyatt patent

21 Graph made by Walker at Shell Oil Co. Well —Cosbloom #1 Dec. 12, 1935, with Depthograph apparatus having no acoustically tuned resonator therein

22 Copy of Drawing made by Walker on blackboard in Court at the trial to illustrate typical conditions in well and pressure and rarefaction waves

23 Commercial Graph made by Walker at Well —Alamitos No. 39, Mar. 6, 1936, with Depthograph having no acoustically [682] tuned resonator therein and with no tubing in the well

24 Graph made by Walker at Well—Nesa #1, Mar. 7, 1936 with Depthograph apparatus having no acoustically tuned resonator therein and with no tubing in the well

25 Charts made with Depthograph on Well #109 showing effects of use of acoustically tuned resonator when tuned to tubing collars and when tuned to casing joints

26 Chart made with Depthograph on Well at El Segundo Apr. 24, 1937 showing effects of use of acoustically tuned resonator

27 Photograph of Depthograph apparatus

28 Photograph of Depthograph apparatus and man operating same

29 Copy of Drawing made by Walker on blackboard in Court at the trial to illustrate effects of tubing collars, casing joints and perforations in pipe on charts made with directional and non-directional microphones

Defendant's Exhibits

C Graph made by Echo-Meter at the trial in demonstrating apparatus to the Court in recording echoes in rubber hose

D Graphs made by Echo-Meter in demonstrating apparatus to Plaintiff before trial at [683] Union

Oil Co. Well Callender #79 and showing graphs made without filter, with filter adjusted properly and with filter maladjusted

E Hot wire microphone—physical exhibit

F Graph made at Duncan, Okla. by apparatus constructed by Defendant in accordance with patent to Lehr and Wyatt No. 2,047,974 using a hot wire microphone

F-1 Same as Exhibit F with marks placed thereon by Dr. Mackeown at the trial

G Graph made at Duncan, Okla. by apparatus constructed by Defendant in accordance with Lehr and Wyatt patent 2,047,974 using a carbon microphone

H Photograph showing Lehr and Wyatt apparatus built by Defendant attached to the well at Duncan, Okla. on which tests were made

I Photograph showing Wyatt and Lehr apparatus using carbon microphone attached to the well at Duncan, Okla.

J Photograph of Defendant's commercial apparatus, the Echo-Meter

K-1 Prior Publication—Wilde and Moore—1931

K-2 Prior Publication—Gill—1932

K-3 Prior Publication—Hawthorn—1933

K-4 Prior Publication—Tucker—1923

K-5 Prior Publication—Ihrig—1935

K-8 (page 194 only) Prior Publication—Millikan—1930 [684]

K-9 Prior Publication—Vietti—1931

L File Wrapper and Contents of Walker ap-

plication, Serial No. 164,534 filed September 18, 1937, disclosing electrical recording system

O-2 Prior Patent—Batcheller 602,422, April 19, 1898

O-4 Prior Patent—Fessenden 1,240,328, September 18, 1917

O-5 Prior Patent—Tucker 1,351,356, August 21, 1920

O-7 Prior Patent—Williams 1,671,262, May 29, 1928

O-9 Prior Patent—Taylor 1,847,636, March 1, 1932

O-13 Prior Patent—Scott 2,173,426, August 30, 1937

O-14 Prior Patent—Halliburton 2,201,311, May 21, 1940

Q File Wrapper and contents of Walker application Serial No. 171,170 filed October 26, 1937 on Method of Determining Fluid Density, etc.

R File Wrapper and contents of Walker Patent 2,161,733 granted June 6, 1939 on Method of Determining Fluid Density, etc. (The application which resulted in this patent was a "continuation" of Exhibit Q)

S File Wrapper and contents of Walker Reissue Patent 21,383 (in suit), granted March 5, 1940, on Method of [685] Determining Fluid Density, etc. (This patent is a reissue of Exhibit R)

T File Wrapper and contents of Walker Patent 2,156,519 (in suit) granted May 2, 1939 for Means for Measuring the Location of Obstructions in Wells

U File Wrapper and contents of Wyatt and

Lehr patent 2,047,974 granted July 21, 1936 for Method and Apparatus for Measuring Well Depths.

Two copies of the designated proceedings, testimony, and abridged exhibits 10, 11, 12 and 11-C are filed herewith.

FRANK L. A. GRAHAM
EARL BABCOCK
Attorneys for Defendant-Appellee

Service of a copy of this designation, together with a copy of the designated proceedings, testimony and abridged Exhibits 10, 11, 11-C and 12, is hereby acknowledged.

HAROLD W. MATTINGLY
Attorney for Plaintiffs-Appellees

June 1, 1943

[Endorsed]: Filed June 1, 1943. [686]

[Title of District Court and Cause.]

DESIGNATION OF CONTENTS OF RECORD ON APPEAL OF PLAINTIFFS TO BE ADDED TO THE DESIGNATION BY DEFENDANT ON ITS APPEAL

To the Clerk of the above entitled Court:

You are hereby requested for plaintiffs' appeal to add to the transcript of the record designated by defendant in its appeal hereinafter mentioned items to make a single record in the appeals of plaintiffs

and defendant, said record to be filed in the United States Circuit Court of Appeals for the Ninth Circuit pursuant to such appeals. [687]

The additional items are as follows:

(1) Statement of Points on which plaintiffs and cross-appellants intend to rely on appeal.

(2) The Amended Answer of defendant filed on or about April 13, 1942.

(3) Plaintiffs' Notice of Appeal filed May 17, 1943.

(4) Plaintiffs' Exhibit 3—Walker patent No. 2,209,944.

(5) Plaintiffs' Exhibit 13—Stipulation as to Certain Facts.

(6) This designation.

(7) Excerpts from the Reporter's Transcript of Testimony and Proceedings on Trial and Reporter's Transcript of Arguments.

Two copies of the designated excerpts from the Reporter's Transcript of Testimony and Proceedings on Trial and Arguments, and Exhibit 13 are filed herewith.

HAROLD W. MATTINGLY
ROBERT W. FULWIDER
Attorneys for Plaintiffs and Cross-Appellants

Service of a copy of this Designation, together with a copy of the designated excerpts is hereby acknowledged.

FRANK L. A. GRAHAM
EARL BABCOCK
Attorneys for Defendant and Cross-Appellee

[Endorsed]: Filed June 25, 1943. [688]

[Title of District Court and Cause.]

STIPULATION AND ORDER EXTENDING DEFENDANT-CROSS APPELLEE'S TIME FOR FILING DESIGNATION OF ADDITIONAL MATTER TO BE INCLUDED IN THE APPEAL TAKEN BY PLAINTIFFS-CROSS APPELLANTS

It Is Stipulated and Agreed by and between the parties in the above-entitled cause, by their respective counsel, the Court consenting thereto, that the time within which the defendant and cross-appellee may file designation of additional matter to be included in the appeal taken by the plaintiffs and

cross-appellants shall be extended to and including July 7, 1943. [689]

HAROLD W. MATTINGLY
ROBERT W. FULWIDER
Attorneys for Plaintiffs and Cross-Appellants
FRANK L. A. GRAHAM
EARL BABCOCK
Attorneys for Defendant and Cross-Appellee

It Is So Ordered:

PEIRSON M. HALL
Judge

July 2, 1943

[Endorsed]: Filed July 2, 1943. [690]

[Title of District Court and Cause.]

DESIGNATION BY DEFENDANT OF PORTIONS OF THE RECORD TO BE ADDED TO PORTIONS DESIGNATED BY PLAINTIFFS

The Plaintiffs herein for their appeal on Patent No. 2,209,944 having designated certain portions of the record to be added to Defendant's designation on its appeal on Patents No. 2,156,519 and Re 21,383;

Now comes the Defendant, Halliburton Oil Well Cementing Company, and designates the following portions of the record, proceedings and evidence to

be contained in the record on Plaintiffs' appeal on Patent No. 2,209,944 in addition to the portions designated by Plaintiffs.

The additional items are as follows:

(1) Defendant's Exhibit A—Certified copy of [691] File Wrapper and Contents of Abandoned Application for Patent of Cranford P. Walker, Serial No. 270,865, filed Apr. 29, 1939.

(2) Defendant's Exhibit B—Certified Copy of File Wrapper and Contents of Application which Resulted in Patent 2,209,944 in suit, which Application was filed Sept. 25, 1939.

(3) Excerpts from the Reporter's Transcript of Testimony and Proceedings before the District Court. Two copies of these excerpts are filed herewith. For convenience and clarity, these excerpts have been combined with those designated by Plaintiffs and typed for substitution and insertion in the Narrative Statement of Testimony and Proceedings heretofore filed by Defendant.

(4) This Designation.

(5) Order of the District Court Extending Time to File Record and Docket Appeal.

(6) Stipulation Regarding Printing of Exhibits.

(7) Stipulation and order extending time to file this Designation.

FRANK L. A. GRAHAM
EARL BABCOCK
Attorneys for Defendant

Service of a copy of this designation, together with a copy of the designated proceedings and testimony is hereby acknowledged.

HAROLD W. MATTINGLY
ROBERT W. FULWIDER
Attorneys for Plaintiffs

[Endorsed]: Filed July 7, 1943. [692]

[Title of District Court and Cause.]

ORDER EXTENDING TIME TO FILE RECORD AND DOCKET APPEAL

On motion of Frank L. A. Graham and Earl Babcock, attorneys for Defendant-Appellant, and good cause appearing therefor;

It Is Hereby Ordered:

That the time within which the Record on Appeal, as provided in Rules 73, 75 and 76 of the Rules of Civil Procedure, shall be filed with the Circuit Court of Appeals and the appeal there docketed is hereby extended up to and including July 21, 1943.

Dated at Los Angeles, California, June 17 1943

PEIRSON M. HALL
Judge

[Endorsed]: Filed June 17, 1943. [693]

[Title of District Court and Cause.]

ORDERING ENLARGING TIME FOR FILING RECORD AND DOCKETING APPEAL

On motion of the plaintiffs herein, good cause appearing therefor, the time for filing of the record on appeal and for docketing the appeal in the Circuit Court of Appeals in the above entitled cause is hereby enlarged to and including the 21st day of July, 1943.

Dated at Los Angeles, California, this 23rd day of June, 1943.

PAUL J. McCORMICK
United States District Judge

[Endorsed]: Filed June 23, 1943. [694]

[Title of District Court and Cause.]

STIPULATION AND ORDER ENLARGING TIME FOR FILING RECORD AND DOCKETING APPEAL

It Is Stipulated and Agreed by and between counsel for the respective parties hereto that the time for filing of the record on appeal and for docketing the appeals in the Circuit Court of Ap-

peals in the above entitled cause shall be enlarged to and including the 10th day of August, 1943.

HAROLD W. MATTINGLY
ROBERT W. FULWIDER
Attorneys for Plaintiffs
FRANK L. A. GRAHAM
EARL BABCOCK
Attorneys for Defendant

7/14/43

So Ordered:

PEIRSON M. HALL
Judge

[Endorsed]: Filed July 14, 1943. [695]

[Title of District Court and Cause.]

CERTIFICATE OF CLERK

I, Edmund L. Smith, Clerk of the District Court of the United States for the Southern District of California, do hereby certify that the foregoing pages numbered from 1 to 695 inclusive contain full, true and correct copies of: Bill of Complaint; Bill of Particulars (except exhibits); Amended Answer of Defendant; Findings of Fact and Conclusions of Law; Decree; Notice of Appeal; Cost Bond on Appeal; Statement of Points on which Defendant-Appellant Intends to Rely on Appeal; Notice of Appeal to the Circuit Court of Appeals; Bond on Appeal; Statement of Points on which Plaintiffs and Cross-Appellants Intend to Rely on Appeal; Narrative Statement of Testimony and

Proceedings in District Court; Stipulation and Order for Transmission of Exhibits to Ninth Circuit Court of Appeals; Stipulation and Order re Insertion of Excerpts in the Record on Appeal filed by Defendant Herein; Designation of Contents of Record on Appeal; Designation of Contents of Record on Appeal of Plaintiffs to be Added to the Designation by Defendant on its Appeal; Stipulation and Order Extending Defendant-Cross Appellee's Time for filing Designation of Additional Matter to be Included in the Appeal Taken by Plaintiffs-Cross Appellants; Designation by Defendant of Portions of the Record to be added to Portions Designated by Plaintiffs; Order Extending Time to File Record and Docket Appeal; Order Enlarging Time for Filing Record and Docketing Appeal and Stipulation and Order Enlarging Time for Filing Record and Docketing Appeals which, together with Original Exhibits transmitted herewith, constitute the record on appeal to the Circuit Court of Appeals for the Ninth Circuit.

I further certify that my fees for comparing, correcting and certifying the foregoing record amount to $93.45 of which amount $84.90 has been paid to me by defendant-appellant and $8.55 has been paid to me by plaintiffs-cross appellants.

Witness my hand and the seal of said District Court this 29 day of July, 1943.

(Seal) EDMUND L. SMITH,
Clerk
By THEODORE HOCKE
Deputy Clerk.

[Endorsed]: No. 10513. United States Circuit Court of Appeals for the Ninth Circuit. Halliburton Oil Well Cementing Company, a Delaware Corporation, Appellant, vs. Cranford P. Walker, and Cranford P. Walker, D. A. Walker, Robert P. Miller and Milo C. Ketchum, doing business as Depthograph Company, a copartnership, Appellees. Cranford P. Walker, and Cranford P. Walker, D. A. Walker, Robert P. Miller and Milo C. Ketchum, doing business as Depthograph Company, a copartnership, Appellants, vs. Halliburton Oil Well Cementing Company, a Delaware corporation, Appellee. Transcript of Record. Upon Appeals from the District Court of the United States for the Southern District of California, Central Division.

Filed August 2, 1943.

PAUL P. O'BRIEN,

Clerk of the United States Circuit Court of Appeals for the Ninth Circuit.

In the United States Circuit Court of Appeals for the Ninth Circuit

CIVIL

No. 10513

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware Corporation,

Defendant-Appellant,

v.

CRANFORD P. WALKER; and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as DEPTHOGRAPH COMPANY, a co-partnership,

Plaintiffs-Appellees.

STATEMENT OF POINTS ON WHICH DEFENDANT-APPELLANT INTENDS TO RELY ON APPEAL

Comes now the Defendant-Appellant in the above entitled cause and, in accordance with Rule 19 (6) of the United States Circuit Court of Appeals for the Ninth Circuit, states that on the appeal the following points will be relied on:

1. The District Court erred in adjudging United States Letters Patent 2,156,519 good and valid in law and particularly as to claims 1, 13, 14, 15 and 17 thereof.

2. The District Court erred in adjudging that the defendant Halliburton Oil Well Cementing

Company has infringed United States Letters Patent 2,156,519, and particularly claims 1, 13, 14, 15 and 17 thereof.

3. The District Court erred in finding that the claims of United States Letters Patent 2,156,519 define invention over the prior art.

4. The District Court erred in according United States Letters Patent 2,156,519 a broad range of equivalents, particularly after having found it to be merely an "improvement" patent.

5. The District Court erred in finding that an electrical filter circuit as part of an electrical sound recording system is the equivalent of a mechanical acoustically tuned resonator (a pipe of a particular length) as part of a mechanical recording system.

6. The District Court erred in not finding that the proceedings in the Patent Office estop Plaintiffs from asserting that an electrical filter circuit is the equivalent of an acoustically tuned resonator in the apparatus of United States Letters Patent 2,156,519.

7. The District Court erred in not finding that mechanical acoustically tuned resonators were old and well known in the art prior to United States Letters Patent 2,156,519 and that no invention was involved in using an acoustically tuned resonator in known mechanical sound recording systems, particularly those of the claims of United States Letters Patent 2,156,519 in suit.

8. Having found that it was old in the art prior to United States Letters Patent 2,156,519 to fire a

gun into a pipe and mechanically record the echo from an obstruction in the pipe, and having found that it was also old in the art to inject into a well casing a charge of gas from a cylinder of gas under pressure and record electrically the echoes from obstructions in the well, the District Court erred in finding that the apparatus of United States Letters Patent 2,156,519 differs from and is an improvement over the prior art and particularly in finding that invention is involved in the incorporation into such old apparatus of tuned acoustical means (a pipe of a particular length.)

9. The District Court erred in adjudging United States Reissue Letters Patent 21,383 good and valid in law as to each of the claims thereof.

10. The District Court erred in adjudging that defendant Halliburton Oil Well Cementing Company has infringed all or any of the claims of United States Letters Patent Reissue 21,383, and particularly that defendant Halliburton Oil Well Cementing Company should be enjoined from "using, practicing or selling or causing to be used, practiced or sold any method for determining pressure in the fluid column of a well, or determining density of the fluid in the fluid column in a well, or determining the production capacity, productivity index or potential of a well which includes the steps of taking two gas pressure measurements and two corresponding fluid level measurements and comparing them."

11. The District Court erred in finding that the

claims of United States Letters Patent Reissue 21,383 define invention over the prior art.

12. The District Court erred in not finding that claims 1 to 8, inclusive, of United States Letters Patent Reissue 21,383 are limited to the determination of density of fluid and that any process which does not include the determination of density is not an infringement of said claims 1 to 8, inclusive.

13. The District Court erred in not finding that during the prosecution of the application for United States Letters Patent 2,161,733, (the original of Reissue 21,383) all the claims were intentionally and expressly limited to the determination of density and that claims not limited to the determination of density were cancelled and abandoned and that therefore claims 9, 10 and 11 of Reissue 21,383 must be interpreted as also limited to the determination of density to save them from a holding of invalidity.

14. The District Court erred in not finding that the only novelty in United States Letters Patent Reissue 21,383 resides in the mental of mathematical steps of "dividing", "comparing", "determining," etc. which do not constitute patentable subject matter.

15. The District Court erred in not finding that Plaintiffs, by this action are attempting to assert a broad and dominating monopoly wholly unsupported by any alleged invention made by Cranford P. Walker, Plaintiff, and wholly unsupported by any alleged invention disclosed in United States

Letters Patent 2,156,519 and Reissue 21,383, and in not finding that the commercial success enjoyed by Plaintiffs in their Depthograph business is due primarily to the inventions of the prior art and Plaintiffs' exploitation thereof, rather than to the alleged inventions of Patents 2,156,519 and Reissue 21,383 in suit.

FRANK L. A. GRAHAM
EARL BABCOCK,
Attorneys for Defendant-Appellant

Service of a copy of this Statement of Points on Which Defendant-Appellant Intends to Rely on Appeal is hereby acknowledged.

HAROLD W. MATTINGLY
ROBERT W. FULWIDER
Attorneys for Plaintiffs-Appellees

[Endorsed]: Filed Aug. 2, 1943. Paul P. O'Brien, Clerk.

In the United States Circuit Court of Appeals for the Ninth Circuit

Appeal No. 10513

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Defendant-Appellant

v.

CRANFORD P. WALKER; and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as DEPTHOGRAPH COMPANY, a co-partnership,

Plaintiffs-Appellee.

CRANFORD P. WALKER; and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as DEPTHOGRAPH COMPANY, a co-partnership,

Plaintiffs-Appellants

v.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Defendant-Appellee

DESIGNATION OF HALLIBURTON OIL WELL CEMENTING COMPANY AS DE-

FENDANT-APPELLANT IN THE FIRST APPEAL AND AS DEFENDANT-APPELLEE IN THE SECOND APPEAL.

To the Clerk of the above-entitled Court:

Halliburton Oil Well Cementing Company as Defendant-Appellant in the first appeal and as Defendant-Appellee in the second appeal, hereby designates the parts of the record which it deems necessary for consideration on both appeals herein; said parts to be printed from the record, proceedings and evidence contained in the certified record transmitted by the Clerk of the United States District Court for the Southern District of California to this Court.

You are hereby requested to include and reproduce in a printed record in the above-entitled appeals the following:

(1) The entire Certified Transcript of Record, certified to the Circuit Court of Appeals by the Clerk of the District Court.

(2) Stipulation and Order regarding the printing of Exhibits, (filed herewith).

(3) This Designation.

(4) Statement of points on which Defendant-Appellant intends to rely on appeal, (filed herewith).

(5) The following Exhibits:

Plaintiffs' Exhibits

1 Walker patent 2,156,519 in suit.
2 Walker patent Reissue 21,383 in suit.
3 Walker patent 2,209,944 in suit.

6. Echo-Meter folder describing Defendant's Apparatus.

7 Echo-Meter advertisement.

8-A, 8-B, 8-C, 8-D Echo-Meter Field Data, Surf Associates Well - State #1.

9 Echo-Meter Field Data on Surf Associates Well - State #1.

10, 11, 12 Plaintiffs' Interrogatories and Defendant's Answers thereto (combined and abridged).

10-A Drawing - Plaintiffs' illustration of Defendant's apparatus.

10-B Graphs made by Defendant's Echo-Meter on Cities Service Well - Ray B-2.

10-C Graphs made by Defendant's Echo-Meter on Phillips Petroleum Co. Well, Kraft #3.

11-A Graph made by Defendant's Echo-Meter on Union Oil Co. Well—Stinson #1.

11-B Graph made by Defendant's Echo-Meter on Pace Pet. Corp. Well—McMasters B-1.

11-C Echo-Meter Field Manual (abridged).

12-A Drawing of Echo-Meter Casinghead Unit.

12-B Photograph of Echo-Meter Casinghead Unit.

12-C Photograph of parts of Echo-Meter Casinghead Unit.

12-D Photograph of Echo-Meter Electrical Recording Instrument.

12-E Calibration curve used to calibrate Filter in Defendant's Echo-Meter Recorder.

13 Stipulation as to Certain Facts.

14 Drawing—Plaintiffs' Illustration of Defend-

ant's Apparatus (the drawing of Exhibit 10-A slightly modified).

18 Prior art patent to Lehr and Wyatt, 2,047,-974.

19 Graph made by Walker at Shell Oil Co. Well Cosbloom No. 1, Nov. 19, 1935, in attempt to operate apparatus like that of Lehr and Wyatt patent.

20 Graph made by Walker on Nov. 20, 1935 in attempt to operate apparatus like that of Lehr and Wyatt patent.

21 Graph made by Walker at Shell Oil Co. Well —Cosbloom #1, Dec. 12, 1935, with Depthograph apparatus having no acoustically tuned resonator therein.

22 Copy of Drawing made by Walker on blackboard in Court at the trial to illustrate typical conditions in well and pressure and rarefaction waves.

23 Commercial graph made by Walker at Well —Alamitos No. 39, Mar. 6, 1936, with Depthograph having no acoustically tuned resonator therein and with no tubing in the well.

24 Graph made by Walker at Well—Nesa #1, Mar. 7, 1936 with Depthograph apparatus having no acoustically tuned resonator therein and with no tubing in the well.

25 Charts made with Depthograph on Well #109 showing effects of use of acoustically tuned resonator when tuned to tubing collars and when tuned to casing joints.

26 Chart made with Depthograph on Well at El Segundo Apr. 24, 1937 showing effects of use of acoustically tuned resonator.

27 Photograph of Depthograph apparatus.

28. Photograph of Depthograph apparatus and man operating same.

29 Copy of Drawing made by Walker on blackboard in Court at the trial to illustrate effects of tubing collars, casing joints and perforations in pipe on charts made with directional and non-directional microphones.

Defendant's Exhibits

A Certified copy of File Wrapper and Contents of Abandoned Application for Patent of Cranford P. Walker, Serial No. 270,865, filed Apr. 29, 1939.

B Certified Copy of File Wrapper and Contents of Application which Resulted in Patent 2,209,944 in suit, which Application was filed Sept. 25, 1939.

C Graph made by Echo-Meter at the trial in demonstrating apparatus to the Court in recording echoes in rubber hose.

D Graphs made by Echo-Meter in demonstrating apparatus to Plaintiff before trial at Union Oil Co. Well Callender #79 and showgraphs made without filter, with filter adjusted properly and with filter maladjusted.

E Hot wire microphones—physical exhibit.

F Graph made at Duncan, Okla. by apparatus constructed by Defendant in accordamce with patent to Lehr and Wyatt No. 2,047,974 using a hot wire microphone.

F-1 Same as Exhibit F with marks placed thereon by Dr. Mackeown at the trial.

G Graph made at Duncan, Okla. by apparatus constructed by Defendant in accordance with Lehr

and Wyatt patent 2,047,974 using a carbon microphone.

H Photograph showing Lehr and Wyatt apparatus built by Defendant attached to the well at Duncan, Okla. on which tests were made.

I Photograph showing Wyatt and Lehr apparatus using carbon microphone attached to the well at Duncan, Okla.

J Photograph of Defendant's commercial apparatus, the Echo-Meter.

K-1 Prior Publication—Wilde and Moore—1931.

K-2 Prior Publication—Gill—1932.

K-3 Prior Publication—Hawthorn—1933.

K-4 Prior Publication—Tucker—1923.

K-5 Prior Publication—Ihrig—1935.

K-8 (page 194 only).
Prior Publication—Milliken—1930.

K-9 Prior Publication—Vietti—1931.

L File Wrapper and Contents of Walker application, Serial No. 164,534 filed September 18, 1937, disclosing electrical recording system.

O-2 Prior Patent—Batcheller 602,422, Apr. 19, 1898.

O-4 Prior Patent—Fessenden 1,240,328, Sept. 18, 1917.

O-5 Prior Patent—Tucker 1,351,356, Aug. 21, 1920.

O-7 Prior Patent—Williams 1,671,262, May, 29, 1928.

O-9 Prior Patent—Taylor 1,847,636, Mar. 1, 1932.

O-13 Prior Patent—Scott 2,173,426, Aug. 30, 1937.

O-14 Prior Patent—Halliburton 2,201,311, May 21, 1940.

Q File Wrapper and contents of Walker application Serial No. 171,170 filed October 26, 1937 on Method of Determining Fluid Density, etc.

R File Wrapper and contents of Walker Patent 2,161,733 granted June 6, 1939 on Method of Determining Fluid Density, etc. (The application which resulted in this patent was a "continuation" of Exhibit Q).

S File Wrapper and contents of Walker Reissue Patent 21,383 (in suit), granted Mar. 5, 1940, on Method of Determining Fluid Density, etc. (This patent is a reissue of Exhibit R).

T File Wrapper and contents of Walker Patent 2,156,519 (in suit) granted May 2, 1939 for Means for Measuring the Location of Obstructions in Wells.

U File Wrapper and contents of Wyatt and Lehr patent 2,047,974 granted July 21, 1936 for Method and Apparatus for Measuring Well Depths.

For use in printing the record, the attention of the Clerk is called to the fact that the "Record on Appeal" filed herewith, contains abridged forms of Exhibits 10, 11, 12 and 11-C. It is asked that these be printed rather than original Exhibits 10, 11, 12 and 11-C. It is asked that all the other exhibits designated, except physical Exhibit E, be

printed from the original exhibits sent to the Court of Appeals herewith.

FRANK L. A. GRAHAM
EARL BABCOCK
Attorneys for Defendant-Appellant
Attorneys for Defendant-Appellee

Service of copy of this designation is hereby acknowledged this 22nd day of July, 1943.

HAROLD W. MATTINGLY
Attorneys for Plaintiffs-Appellee
ROBERT W. FULWIDER
Attorneys for Plaintiffs-Appellant

[Endorsed]: Filed Aug. 2, 1943. Paul P. O'Brien, Clerk.

In the United States Circuit Court of Appeals for the Ninth Circuit

No. 10513

HALLIBURTON OIL WELL CEMENTING COMPANY,

Appellant,

v.

CRANFORD P. WALKER; and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as DEPTHOGRAPH COMPANY, a co-partnership,

Appellees.

STIPULATION REGARDING PRINTING OF EXHIBITS

It is hereby stipulated by and between counsel for the respective parties, the Circuit Court of Appeals for the Ninth Circuit consenting thereto, that only ten (10) copies of the books of exhibits be printed, six copies for the use of the Court and four copies for the use of counsel, two to each party.

It is further stipulated that the following exhibits be included in the printed books of exhibits and that, except for Defendant's physical Exhibit "E", the books of exhibits shall constitute all the exhibits before the Circuit Court of Appeals for the Ninth Circuit on this appeal:

Plaintiffs' Exhibits 1, 2, 3, 6, 7, 8-A, 8-B, 8-C.

8-D, 9; a combined and abridged draft of Exhibits 10, 11 and 12; 10-A, 10-B, 10-C, 11-A, 11-B; an abridged draft of Exhibit 11-C; 12-A, 12-B, 12-C, 12-D, 12-E, 13, 14, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29;

Defendant's Exhibits A, B, C, D, F, F-1, G, H, I, J, K-1, K-2, K-3, K-4, K-5; page 194 only of Exhibit K-8; K-9, L, O-2, O-4, O-5, O-7, O-9, O-13, O-14, Q, R, S, T, U.

It is further stipulated that Plaintiffs' Exhibit 18, the prior art patent to Lehr and Wyatt No. 2,047,974, be bound in the book of exhibits following Defendant's Exhibit O-9, instead of Plaintiffs' exhibits, so that all the prior art patents will appear in the record in one place, and the Clerk is requested to have the book of exhibits so bound.

FRANK L. A. GRAHAM
EARL BABCOCK
Attorneys for Defendant-Appellant

HAROLD W. MATTINGLY
ROBERT W. FULWIDER
Attorneys for Plaintiffs-Appellees

So Ordered:

ALBERT LEE STEPHENS
Judge,
United States Circuit Court of Appeals Ninth Circuit

[Endorsed]: Filed Aug. 2, 1943. Paul P. O'Brien, Clerk.

[Title of Circuit Court of Appeals and Cause.]

PLAINTIFFS' DESIGNATION OF THE PARTS OF THE RECORD TO BE INCLUDED IN THE PRINTED RECORD AND BOOK OF EXHIBITS FOR PLAINTIFFS' APPEAL

A. For the printed record:

(All reference to page numbers made herein refers to the page numbers of the Transcript of Record, as certified to this Court).

1. Those parts of the Complaint as follows:

(a) Introduction (Page 3).

(b) Paragraphs numbered I, II, III, IV, VII, VIII, IX, X (Pages 3, 4, 5 and 6).

(c) Prayer (Page 6).

2. Those parts of the Amended Answer as follows:

(a) Introduction (Page 10).

(b) Paragraphs I, II, III, IV, VII, VIII, IX, X, XI, XII, XIII, XIX(a) only, XXII, XXIII, XXIV, XXXIV (Pages 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 24).

(c) Prayer (Page 24).

3. Those parts of the Findings of Fact and Conclusions of Law as follows:

(a) Introduction (Page 25).

(b) Paragraphs of Findings of Fact—1, 2, 3, 4, 5 and 7 (Pages 25 and 26).

(c) Paragraphs of Conclusions of Law—I, II VII (Pages 28 and 29).

4. The Decree (Pages 31, 32, 33).

5. Plaintiffs' Notice of Appeal (Page 41).

6. Those parts of the Narrative Statement of Testimony and Proceedings in District Court as follows:

Page 48, Lines 1 through 22
Page 51, Lines 8 through 12
Page 57, Line 8 through Page 61, Line 7
Page 62, Line 13 through Page 72, Line 19
Page 82, Line 18 through Page 87, Line 9
Page 99, Line 18 to end of page
Page 105, Line 1 through Page 106, Line 8
Page 116, Line 15 through Page 119, Line 14
Page 120, Line 1 to end of page
Page 121, Line 1, through Page 122, Line 17
Page 131, last line only, through Page 135, Line 4
Page 154, Line 1 through Page 193, Line 1
Page 198, Line 10 through Page 203, Line 15
Page 204, Line 13 through Page 207, Line 15
Page 218, Line 7, through Page 220, Line 24
Page 230, Lines 7 through 21
Page 234, Line 18 through Page 243, Line 8
Page 248, Lines 1 through 15
Page 258, Line 17 through Page 261, last line
Page 268, Lines 1 through 10
Page 268, Line 21 though Page 269, Line 11
Page 273, Line 13 through Page 278, Line 14
Page 543, Line 1, through Page 552, Line 8

7. Statement of Points upon which Plaintiffs will rely on their appeal. (Filed in the Circuit Court of Appeals)

8. This designation.

B. For the Book of Exhibits:

1. Plantiffs' Exhibit 3 Walker Patent 2,209,-944 (copies to be furnished by Plaintiffs).
2. Plaintiffs' Exhibit 19
3. Plaintiffs' Exhibit 20
4. Plaintiffs' Exhibit 21
5. Plaintiffs' Exhibit 13.
6. Defendant's Exhibit T.

Dated at Los Angeles, California, this 10th day of August, 1943.

HAROLD W. MATTINGLY
ROBERT W. FULWIDER
Attorneys for Plaintiffs-Appellants

Received service of the within Plaintiffs' Designation of the Parts of the Record, etc. this 10th day of August, 1943.

FRANK L. A. GRAHAM
Attorney for Defendant-Appellee

[Endorsed]: Filed Aug. 14, 1943. Paul P. O'Brien, Clerk.

In the United States Circuit Court of Appeals for the Ninth Circuit

Appeal No. 10513

CRANFORD P. WALKER; and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as DEPTHOGRAPH COMPANY, a co-partnership,

Plaintiffs-Appellants,

v.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Defendant-Appellee.

STATEMENT OF POINTS TO BE RELIED UPON BY PLAINTIFFS-APPELLANTS, CRANFORD P. WALKER, et al.

Plaintiffs-Appellants, Cranford P. Walker, and Cranford P. Walker, D. A. Walker, Robert P. Miller and Milo C. Ketchum, doing business as Depthograph Company, hereby adopt as their statement of points on appeal the document filed in the District Court on June 25, 1943, entitled "State ment of Points on which Plaintiffs and Cross-Appellants Intend to Rely on Appeal", of which the following is a copy:

"1. The District Court erred in adjudging United States Letters Patent 2,209,944 invalid.

2. The District Court erred in adjudging United

States Letters Patent No. 2,209,944 invalid as to each of the claims thereof as defining methods which do not involve invention and are unpatentable.

3. The District Court erred in failing to find that the claims of United States Letters Patent No. 2,209,944 and each of them define patentable invention over the prior art.

4. The District Court erred in failing to find that the claims of United States Letters Patent No. 2,209,944 and each of them define a patentable method comprising a series of physical steps to produce information from which the results described may be computed.

5. The District Court erred in failing to find that the only prior art submitted by the defendant pertaining to the questions of anticipation and lack of invention were the same prior art which had been considered by the United States Patent Office during the prosecution of the applications resulting in United States Letters Patent No. 2,209,944 and that said Letters Patent and each of the claims thereof define patentable invention over any of such prior art.

6. The District Court erred in failing to find that the invention set forth and claimed in United States Letters Patent No. 2,209,944 was a very meritorious invention, constituted a distinct advance in the art to which it relates, solved successfully for the first time a problem on which others had made many attempts but had never succeeded

and that said patent is entitled to a liberal interpretation.

7. The District Court erred in finding that 'United States Letters Patent No. 2,209,944 is a method patent and discloses and claims certain methods of determining the locations of obstructions in a well by introducing into the well a pressure wave and the recording of echoes from the various known obstructions or partial obstructions in the well, and calculating from information so acquired the location of the obstructions. The novelty of this structure consists only in the performance of mental steps such as "counting", "observing", "computing" and "comparing", which do not involve invention.'

8. The District Court erred in failing to find that none of the prior art before the Court disclosed or taught the methods defined in the claims of United States Letters Patent No. 2,209,944.

9. The District Court erred in failing to find that the novelty in the methods defined in the claims of United States Letters Patent No. 2,209,944 is more than the mere performance of mental steps and does involve invention.

10. The District Court erred in failing to find that the defendant has infringed each and every of the claims of United States Letters Patent No. 2,209,944.

11. The District Court erred in not awarding costs of suit to plaintiffs."

Dated at Los Angeles, California, this 10th day of August, 1943.

HAROLD W. MATTINGLY
ROBERT W. FULWIDER
Attorneys for Plaintiffs-Appellants

Received service of the within Statement of Points, etc. this 10th day of August, 1943.

FRANK L. A. GRAHAM
Attorney for Defendant-Appellee

[Endorsed]: Filed Aug. 14, 1943. Paul P. O'Brien, Clerk.

CLERK'S COPY.

Vol. III

TRANSCRIPT OF RECORD

(Pages 557 to 782)

Supreme Court of the United States

OCTOBER TERM, [redacted] 1946

No. [redacted] 24

HALLIBURTON OIL WELL CEMENTING COMPANY, PETITIONER,

vs.

CRANFORD P. WALKER AND CRANFORD P. WALKER, D. A. WALKER, ET AL., DOING BUSINESS AS DEPTHOGRAPH COMPANY, COPARTNERSHIP

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT

PETITION FOR CERTIORARI FILED AUGUST 2, 1946.

CERTIORARI GRANTED OCTOBER 14, 1946.

Office - Supreme Court, U. S.
FILED
AUG 2 1945
CHARLES ELMORE CROPLEY
CLERK

TRANSCRIPT OF RECORD
IN SIX VOLUMES

IN THE

Supreme Court of the United States

October Term, 1945

No. 290

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Petitioner,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Respondents.

VOLUME III

Book of Exhibits (Plaintiffs' Exhibits)

Pages 587 to 781

UPON PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT

Rotary Colorprint, 651 Howard Street, San Francisco

No. 10513

United States
Circuit Court of Appeals
For the Ninth Circuit.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Appellant,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Appellees.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Appellants,

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Appellee.

Transcript of Record
In Five Volumes

VOLUME III
Book of Exhibits
(Plaintiffs' Exhibits)
Pages 587 to 781

Upon Appeals from the District Court of the United States for the Southern District of California, Central Division

Rotary Colorprint, 590 Folsom St., San Francisco

INDEX

Page

Exhibits for Defendant:

A—Certified Copy of File Wrapper and Contents of Abandoned Application of Cranford P. Walker, No. 270,865, filed April 29, 1939 783-832

B—Certified Copy of File Wrapper and Contents of Application which Resulted in Patent No. 2,209,944, in suit, filed Sept. 25, 1939 832-882

C—Graph made by Echo-Meter at the Trial in Demonstrating Apparatus to the Court in Recording Echoes in Rubber Hose 883

D—Graphs made by Echo-Meter in Demonstrating Apparatus to Plaintiff before Trial at Union Oil Co. Well Callender #79 884

F—Graph made at Duncan, Okla., by Apparatus constructed by Defendant in accordance with Patent to Lehr and Wyatt No. 2,047,974 using a hot wire microphone 885

F-1—Same as Exhibit F with marks placed thereon by Dr. Mackeown at the Trial 886

Index **Page**

Exhibits for Defendant—(Continued):

G—Graph made at Duncan, Okla. by Apparatus constructed by Defendant in accordance with Lehr and Wyatt Patent 2,047,974 using a carbon microphone 887

H—Photograph showing Lehr and Wyatt Apparatus built by Defendant attached to the well at Duncan, Okla. on which tests were made 888

I—Photograph showing Wyatt and Lehr Apparatus using Carbon Microphone attached to the Well at Duncan, Okla. 889

J—Photograph of Defendant's Commercial Apparatus, the Echo-Meter 890

K-1—Prior Publication—Wilde and Moore, 1931 891-897

K-2—Prior Publication—Gill, 1932....898-903

K-3—Prior Publication—Hawthorn, 1933 904-925

K-4—Prior Publication—Tucker, 1923 926-942

K-5—Prior Publication—Ihrig, 1935..... 943

K-8—Page 194, Prior Publication—Millikan, 1930 945

K-9—Prior Publication—Vietti, 1931 ..947-952

Index **Page**

Exhibits for Defendant—(Continued):

L—File Wrapper and Contents of Walker Application No. 164,534, filed Sept. 18, 1937, Disclosing Electrical Recording System 953-1063

O-2—Prior Patent — Batcheller 602,422, Apr. 19, 1898 1065-1072

O-4—Prior Patent—Fessenden 1,240,328, Sept. 18, 1917 1073-1076

O-5—Prior Patent—Tucker 1,351,356, Aug. 21, 1920 1077-1088

O-7—Prior Patent — Williams 1,671,262, May 29, 1928 1089-1094

O-9—Prior Patent—Taylor 1,847,636, Mar. 1, 1932 1095-1100

O-13—Prior Patent—Scott 2,173,426, Aug. 30, 1937 1107-1130

O-14—Prior Patent—Halliburton 2,201,-311, May 21, 1940 1133-1140

Q—File Wrapper and Contents of Walker Application Serial No. 171,170, filed Oct. 26, 1937, on Method of Determining Fluid Density, etc. 1141-1315

R—File Wrapper and Contents of Walker Patent 2,161,733, granted June 6, 1939 on Method of Determining Fluid Density, etc. 1315-1360

Index Page

Exhibits for Defendant—(Continued):

S—File Wrapper and Contents of Walker Reissue Patent 21,383 (in suit) granted Mar. 5, 1940 1360-1414

T—File Wrapper and Contents of Walker Patent 2,156,519 (in suit) granted May 2, 1939 for Means for Measuring the Location of Obstructions in Wells 1415-1543

U—File Wrapper and Contents of Wyatt and Lehr Patent 2,047,974, granted July 21, 1936 for Method and Apparatus for Measuring Well Depths 1544-1591

Exhibits for Plaintiffs:

1—Walker Patent 2,156,519 in suit....587-598

2—Walker Patent Reissue 21,383 in suit 599-607

3—Walker Patent 2,209,944 in suit...609-617

6—Echo-Meter Folder Describing Defendant's Apparatus 619-629

7—Echo-Meter Advertisement 635-636

8—A, B, C, D, Echo-Meter Field Data, Surf Associates Well—State #1..637-642

9—Echo-Meter Field Data on Surf Associates Well—State #1.....643-645

Index Page

Exhibits for Plaintiffs—(Continued):

10, 11, 12—Plaintiffs' Interrogatories and Defendant's Answers Thereto (combined and Abridged) 646-712

10-A—Drawing — Plaintiffs' Illustration of Defendant's Apparatus 713

10-B—Graphs made by Defendant's Echo-Meter on Cities Service Well—Ray B-2 714

10-C—Graphs made by Defendant's Echo-Meter on Phillips Petroleum Co. Well, Kraft #3 715

11-A—Graph made by Defendant's Echo-Meter on Union Oil Co. Well—Stinson #1 716

11-B—Graph made by Defendant's Echo-Meter on Pace Pet. Corp. Well—McMasters B-1 717

11-C—Echo-Meter Field Manuel 719-753

12-A—Drawing of Echo-Meter Casinghead Unit 754

12-B—Photograph of Echo-Meter Casinghead Unit 755

12-C—Photograph of Parts of Echo-Meter Casinghead Unit 756

12-D—Photograph of Echo-Meter Electrical Recording Instrument 757

Index Page

Exhibits for Plaintiffs—(Continued):

12-E—Calibration Curve used to Calibrate Filter in Defendant's Echo-Meter Recorder 758

13—Stipulation as to Certain Facts....759-767

14—Drawing—Plaintiffs' Illustration of Defendant's Apparatus (Drawing of Ex. 10-A slightly modified)..... 768

18—Prior Art Patent to Lehr and Wyatt, 2,047,974 .....769, 1101

19—Graph made by Walker at Shell Oil Co. Well Cosbloom No. 1, Nov. 19, 1935, in attempt to operate Apparatus like that of Lehr and Wyatt Patent... 771

20—Graph made by Walker on Nov. 20, 1935 in Attempt to Operate Apparatus like that of Lehr and Wyatt Patent.. 772

21—Graph made by Walker at Shell Oil Co. Well—Cosbloom #1, Dec. 12, 1935, with Depthograph Apparatus having no Acoustically Tuned Resonator Therein 773

22—Copy of Drawing made by Walker on Blackboard in Court at Trial to Illustrate Typical Conditions in Well and Pressure and Rarefaction Waves..... 774

Index Page

Exhibits for Plaintiffs—(Continued):

23—Commercial Graph made by Walker at Well—Alamitos No. 39, Mar. 6, 1936, with Depthograph having no Acoustically Tuned Resonator Therein and with no Tubing in the Well..... 775

24—Graph made by Walker at Well—Nesa #1, Mar. 7, 1936, with Depthograph Apparatus having no Acoustically Tuned Resonator Therein and with no Tubing in the Well 776

25—Charts made with Depthograph on Well #109 showing Effects of use of Acoustically Tuned Resonator When Tuned to Tubing Collars and When Tuned to Casing Joints..... 777

26—Chart made with Depthograph on Well —El Segundo, Apr. 24, 1937, showing Effects of use of Acoustically Tuned Resonator 778

27—Photograph of Depthograph Apparatus 779

28—Photograph of Depthograph Apparatus and Man Operating Same..... 780

29—Copy of Drawing made by Walker on Blackboard in Court at Trial to Illustrate Effects of Tubing Collars, Casing Joints and Perforations in Pipe on Charts made with Directional and Non-Directional Microphones 781

PLAINTIFF'S EXHIBIT No. 1

Walker Patent No. 2,156,519

[Endorsed]: Filed Oct. 6, 1942.

588

In suit

May 2, 1939. C. P. WALKER 2,156,519

MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Filed Sept. 7, 1937 2 Sheets-Sheet 1

FIG. 1.

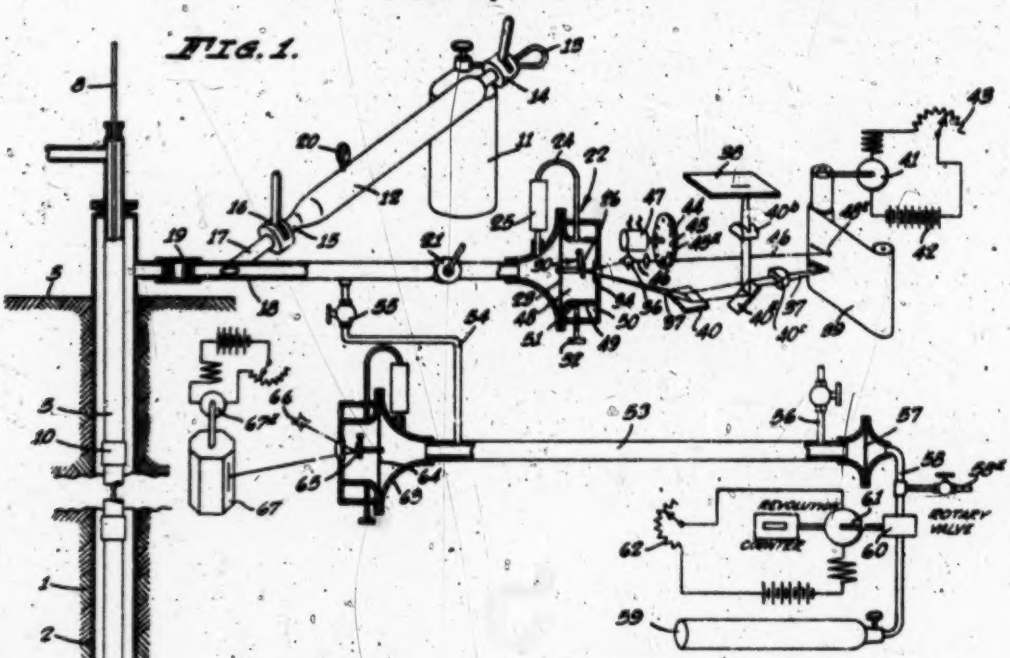


FIG. 2.

FIG. 3.

FIG. 4.

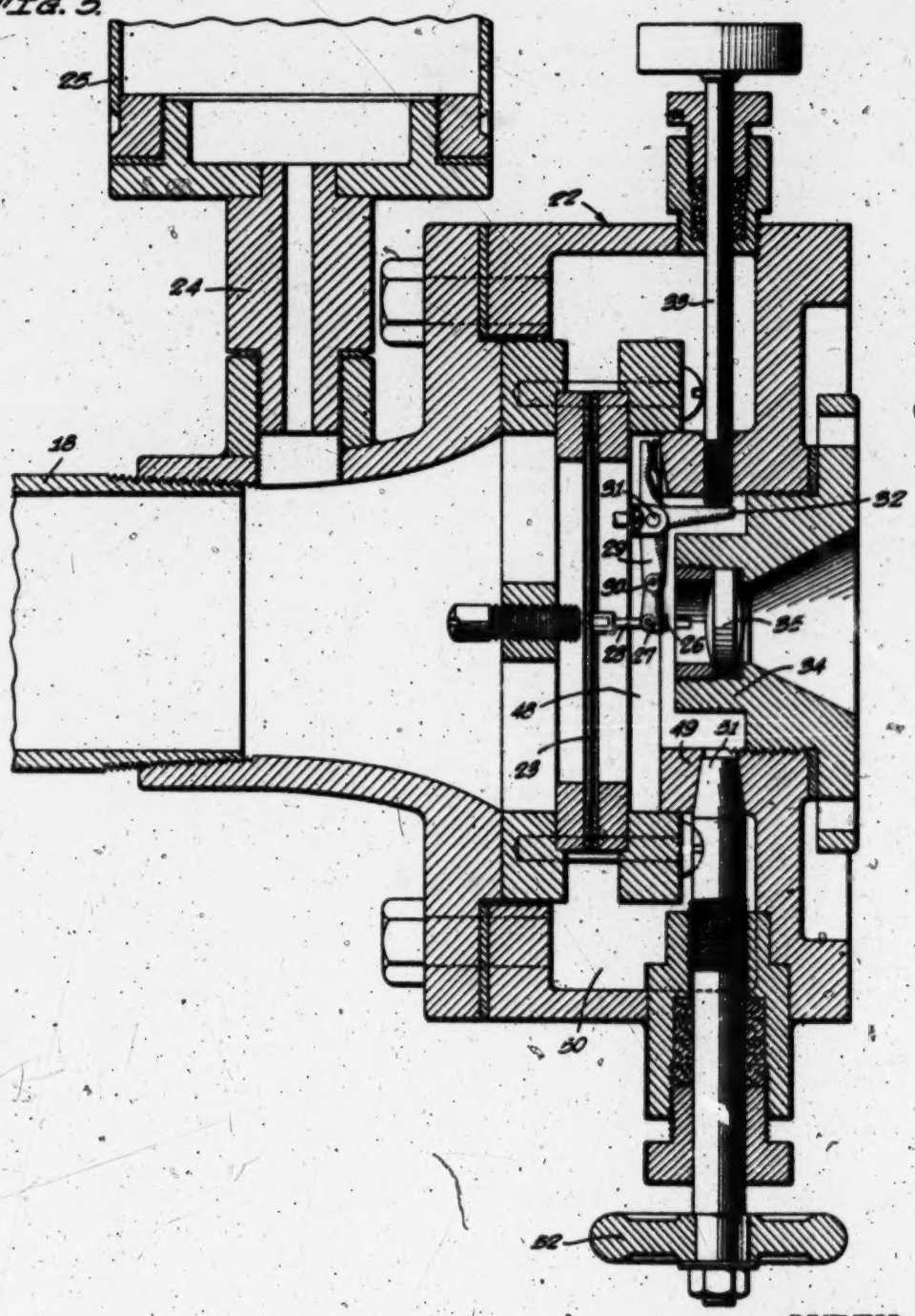
INVENTOR.
CRANFORD P. WALKER
BY Harold W. Mattingly
ATTORNEY

May 2, 1939. C. P. WALKER 2,156,519

MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Filed Sept. 7, 1937 2 Sheets-Sheet 2

FIG. 5.



INVENTOR.
CRANFORD P. WALKER
BY Harold W. Mattingly
ATTORNEY.

Patented May 2, 1939 2,156,519

UNITED STATES PATENT OFFICE

2,156,519

MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Cranford P. Walker, San Marino, Calif.

Application September 7, 1937, Serial No. 162,999

17 Claims. (Cl. 181—0.5)

My invention relates to devices for measuring the location of obstructions in deep wells, such as oil wells, and has particular reference to apparatus for determining the location below the ground surface of the liquid level in the well or the location of tools, pipe sections, couplings or other devices which constrict the well bore.

During the active life of an oil well it is desirable from time to time to determine the location of the fluid level within the well for the purpose of determining the type of pumping apparatus most desirable to be used, determining the rate of flow of oil into the well, and for making other determinations desirable in the most efficient operation of the well.

Prior methods of determining the location of the fluid level or the location of other obstructions in the well have been generally of two types, one in which measuring apparatus has been lowered from the ground surface to determine by the length of cable or line extended into the well the depth or location of the fluid or other obstructions encountered by the instrument as it is lowered. Among devices to be lowered into the well is also included a pressure recorder which may be lowered into the well on a wire, the length of which is metered to determine the static pressure in the well at different levels, a variation of which includes a pressure recorder with a clock driven chart lowered on the bottom of the pump to obtain a record of the operating pressures or levels of the fluid. A further variation is that of lowering a bailer upon a rope and either measuring the wetted surface of the rope or repeatedly lowering the bailer until it brings up fluid, measuring the length of the line upon such occurrence. The other method is that of producing sound waves in the well and noting the elapsed time between the introduction of the sound and its return as an echo from the surface of the fluid or other obstruction encountered.

Neither of these methods is satisfactory, the first having the disadvantage of requiring the removal of oil flow tubing, sucker rods and other apparatus normally disposed in the well prior to the time the instrument is inserted in and lowered into the well, requiring a considerable length of time both for the removal of such apparatus, the reinsertion of the apparatus, and the making of the actual measurement. The other method is unsatisfactory primarily because of the relatively low intensity or energy which can be employed in the sound wave so that the echo received back is of such low energy as to prevent its accurate detection and, further, little or no distinction is made by reason of such low energy between various types of obstructions encountered by sound wave.

A third method, namely, that of introducing a shock of relatively high intensity into the well, creating thereby a pressure wave which travels through the well, and measuring the elapsed time between the introduction thereof and the echo thereof, to give an indication of the depth of the fluid level and other obstructions, has been introduced, one form being that of creating an explosion in the well, another form being illustrated and described in United States Letters Patent No. 2,047,974, issued to Harold J. Wyatt and Paul E. Lehr on July 21, 1936. This latter method has the desirable characteristic of permitting the employment of relatively high intensity in the wave or impulse produced in the well and it is an object of my invention to improve upon the method disclosed in that patent and to eliminate or materially reduce factors of error encountered in the employment of that method.

Another object of my invention is to provide a device for the measurement of the location of fluid level or other obstructions in a well bore in which the pressure impulse introduced into the well produces an indication both of the fluid level and of the location of other obstructions in the well bore.

Another object of my invention is to provide an apparatus of the character set forth in the preceding paragraph wherein the same pressure impulse introduced into the well to measure the fluid level or the location of other obstructions is employed to determine the velocity of the wave in the particular media encountered in the well.

Another object of my invention is to provide an apparatus as set forth in the preceding paragraph wherein, knowing the location of one or more obstructions, tools or other devices in the well bore, the velocity of the wave within the well bore may be accurately determined from echoes produced thereby and enabling an operator to determine the unknown location of the fluid level by the mere measure of the elapsed time between the introduction of the impulse into the well and the reception of a distinguishable echo from the fluid level, without necessitating introduction of corrective factors or other separate measurement of and determination of the character of the media in the well.

Another object of my invention is to provide an apparatus for determining the location of fluid levels in well bores in which the location of and the number of tubing sections in the well may be determined by the same pressure wave

592

created to measure the depth or the location of the fluid level.

Other objects of my invention will be apparent from a study of the following specifications, read in connection with the accompanying drawings, wherein

Fig. 1 is a diagrammatic view illustrating a typical well cross section and the location and character of the apparatus required for determining the fluid level or location of other obstructions in the well in accordance with my method;

Fig. 2 is a diagrammatic view illustrating the type of record or indication which may be made with my method in its simplest application;

Fig. 3 is a diagrammatic view similar to Fig. 2 and illustrating the type of record or indication which may be made with my method but in which echoes produced by intermediate obstructions are not amplified;

Fig. 4 is a diagrammatic view similar to Figs. 2 and 3 and illustrating the type of record or indication which may be made with my method, including the amplification of echoes from intermediate obstructions; and

Fig. 5 is a vertical sectional view taken through one form of mechanical pressure responsive device which may be employed in my method.

The method disclosed in United States Letters Patent issued to Wyatt and Lehr, hereinbefore referred to, is briefly that of introducing into a well bore a pressure impulse, either positive or negative, which may have any desired frequency as by the introduction into the well of a quantity of gas of known pressure and volume, the introduction of this impulse into the well producing a wave which will travel down the well until it encounters the fluid surface in the well and then the wave will be reflected and will travel back up the well to the ground surface where the echo or return wave may be detected, the measurement of the elapsed time between the production of the impulse and the arrival at the ground surface of the echo constituting a measure of the location of the fluid level by the simple calculation of the elapsed time multiplied by the rate of travel or the velocity of the wave in the well. In making such calculations, it is correctly assumed that the velocity of the wave will be the same as that of a sound wave. In air at normal temperatures and approximately sea level pressures, this rate would be 1100 feet per second but the gaseous content or media in the well is ordinarily not the same as air and correction must be made for the density, temperature or other characteristics of the particular media encountered in the well, it being well known that the higher the temperature or the lower the density of the gaseous media through which the impulse travels, the greater the velocity of the wave.

In employing the method as set forth in the said patent, an approximation of the fluid level may be readily determined and this approximation or measurement may be determined in a relatively short length of time, without requiring the removal or disturbance of any of the apparatus contained within the well bore. However, to determine the fluid level with considerable accuracy, the rate of travel of the wave in the particular media encountered in any particular well must be known or must be determined since the density, temperature and character of the gaseous media in wells varies in each different oil field and in each individual well. I provide means for readily determining at any particular well the velocity of the wave in that particular well, which may be arrived at as follows:

In Fig. 1 I have illustrated a typical oil well comprising the earth bore 1, usually lined with casing 2 or pipe of relatively large diameter, extending from the ground surface at 3 to the oil bearing sands at 4 where the casing is either perforated or is provided with a perforated liner through which the oil from the sands may enter to the interior of the casing. The casing is, of course, constructed of a plurality of lengths of pipe secured together by couplings or collars in any well known manner. A second pipe or string of pipes extend down through the casing 2, this string of pipe being known as the oil flow tubing, indicated at 5, extending from the ground surface down to a position disposed below the level of the fluid in the well, which is indicated at 6, the lower end of the tubing string 5 having a pump 7 of any desired character located therein. Such pumps are usually operated by means of a string of sucker rods 8 which extend upwardly through the tubing string 5.

It is the common practice to employ in the tubing string 5 a tubing catcher 9 which may be of any of the well known constructions, the tubing catcher being usually located a relatively short distance above the level of the fluid in the well so that should the tubing string break the tubing catcher 9 will grip the casing and prevent complete destruction of the tubing string. One or more of the tubing catchers 9 may be distributed throughout the length of the tubing string 5.

The tubing string 5 is constructed of a plurality of lengths of pipe coupled together by means of collars 10, which collars are usually of somewhat larger outside diameter than the outside diameter of the tubing from which the oil flow tubing is made.

Hence it will be noted that in the ordinary oil well there are a plurality of obstructions, each of which is capable of receiving and reflecting a sound wave or pressure wave passing down through the well, these obstructions including the fluid surface 6, the tubing catcher 9 and each of the collars 10 of the tubing string.

In most wells the length of the tubing string between the ground surface 3 and the pump 4 is known, that is, records are usually kept showing the length of each tubing string section and the number of such sections located within any given well. Particularly, records are usually kept as to the location along the tubing string of the catcher 9 so that by referring to these records an absolute calculation or determination of the distance between the ground surface and the tubing catcher or liner top is known. Hence to determine the location of the fluid level 6, it is only necessary to produce in the well a pressure impulse which will create the low frequency wave, and then translate the echoes received from the well in terms of echo impulses received from the tubing catcher or liner top and from the liquid surface. By comparing the time lapse between the production of the pressure impulse and the receipt of the echo from the tubing catcher with the time lapse between the creation of the pressure impulse and the receipt of the echo from the fluid surface, a positive and accurate measurement of the location of the fluid level may be obtained. That is, if the known location of the tubing catcher is 5000 feet below the fluid sur-

face and it is desired to know the height of the fluid in the well, all that is necessary is to produce a pressure impulse, note or record the echo from the tubing catcher, and note or record the echo received from the fluid surface. The time lapse between the creation of the pressure impulse and the receipt of the echo from the tubing catcher denotes the velocity of the pressure wave in the particular media encountered in that particular well so that by measuring the additional elapsed time between the receipt of the echo from the tubing catcher and the receipt of the echo from the fluid surface, an accurate measurement may be obtained and no compensation need be made for possible errors due to different velocities of waves in different media because the mean velocity of the wave from the ground surface to the tubing catcher and return is exactly the same as the mean velocity of the wave from the ground surface to the fluid surface and return.

The only item which must be provided for is that of producing a pressure wave echo of such magnitude and of such character that the echo from the tubing catcher can be distinguished from the echo received from the fluid surface.

As illustrated in Fig. 1, this distinction may be readily made by providing a suitable source of fluid pressure indicated at 11 which may be a tank, compressor or other source of fluid pressure at any desired value. It follows, of course, that the pressure impulse which must be produced in the well must be at a greater pressure than the pressure of gases in the well so that the pressure source 11 must be capable of delivering a pressure impulse having a considerable differential over the static pressure of gases in the well or flowing therefrom. For example, if the well gases at the surface of the well are at a pressure of 500 pounds per square inch, the source of fluid pressure 11 must be capable of delivering, say, 600 pounds per square inch or more in order to create a pressure impulse of, for example, 100 pounds pressure differential.

The pressure source 11 is illustrated as being coupled to a pressure chamber 12, one end of which is connected as by means of tube 13 and valve 14 to the pressure source 11, while the opposite end of the pressure chamber 12 is connected by means of a nipple 15, a quick opening valve 16 and a nipple 17 to a length of pipe 18 which is in turn coupled as indicated at 19 to the well casing 2. The pressure chamber 12 is preferably provided with a suitable indicating pressure gage 20 by which the pressure within the pressure chamber 12 may be readily measured. Thus for the production of the pressure wave all that is necessary is to close valve 16, open valve 14 and allow pressure to be built up in the pressure chamber 12 to the desired pressure value, say, 600 pounds per square inch. Then the valve 14 is closed and valve 16 opened, allowing an impulse of 600 pounds per square inch to be injected into the well casing (the static pressure in which is, for example, 500 pounds per square inch).

A receiving device for receiving and registering the echoes of the pressure impulse from the various obstructions within the well is illustrated as including the pipe 18 and pressure responsive device coupled thereto through a valve 21 to a diaphragm chamber 22, permitting a flexible diaphragm 23 to be placed into communication with the casing 2 whenever the valve 21 is opened. To control the sensitivity of response of the diaphragm 23 and in order to prevent undue distortion of the diaphragm 23 by the static pressure in the well and to avoid damage which would result therefrom, I prefer to allow the static pressure in the well casing 2 and pipe 18 to be equalized on both sides of the diaphragm 23 as by providing a by-pass 24 providing a restricted passage through which gas pressure in the chamber 22 on one side of the diaphragm may pass to the opposite side of the diaphragm, the filter 25 being interposed in the by-pass if desired to dry out the gas and prevent undue corrosion of the more delicate parts of the device contained in the diaphragm chamber 22. Attached to the diaphragm 23 is a mirror 26, preferably connected as shown in Fig. 5 upon a link 27, one end of which link is coupled by means of a rod 28 to the diaphragm 23. The opposite end of the link 27 is preferably connected to one arm of a bellcrank lever 29, as indicated at 30. The bellcrank lever 29 is pivoted as at 31 to any desired portion of the metal comprising the diaphragm chamber 22, another arm of the bellcrank lever 29 extending as indicated at 32 to be engaged by an adjusting rod 33 so that by operating the adjusting rod 33 the fulcrum point 30 of the link 27 may be varied as desired to properly position the beam on a recording chart.

In the front wall 34 of the diaphragm chamber 22 I mount a lens 35, through which light from a suitable light source 36 may pass into the chamber 22 to be reflected by the mirror 26, the reflected beam 37 passing back through the lens 35, as a ribbon beam which may be reflected or directed upon a ground glass screen 38 and upon a recording chart or strip of sensitised tape 39 to make a permanent record of the path described by the light beam 37. Suitable reflectors, such as indicated at 40, may be employed to direct the beam in any desired direction while a reflector 40a may be interposed in a portion of the ribbon beam 37 to direct a portion thereof upon the screen 38, suitable condenser lenses 40b and 40c being interposed in the beam to draw the same to a point beam upon the screen 38 and tape 39.

Thus as the pressure within the casing 2 is varied as by the pressure wave resulting from the pressure impulse created within the casing 1, the mirror 26 will be moved, the amplitude of its movement representing the amplitude of the pressure variation. As the echo of the pressure impulse from any obstruction within the well is received upon the diaphragm 23, the mirror 26 will be moved in accordance with the amplitude of the echo impulse and will cause the echo impulses to be registered for observation, both by directing the light beam 37 upon the ground glass 38 where the amplitude of the echo may be visually observed and, by directing the light beam 37 upon the recording tape 39, a permanent record of the pressure wave which is created within the casing 2 may be made and this wave or chart will show peaks of varying amplitude, each of which peaks represents an echo from a particular obstruction within the well, either the tubing collars 18, the tubing catcher 8 or the fluid surface 6.

The sensitised strip 39 may be arranged to be driven at any desired speed by means of a variable speed motor 41 coupled to a suitable source of current 42 through a rheostat or other speed adjusting device 43 so that the tape or strip 39 may be driven at variable speeds.

By employing some device which will produce

upon the record strip 39 a time lapse measurement, a direct comparison between the path described by the light beam and the lapse of time may be accomplished. I prefer to provide such mechanism including means for producing upon the strip 39 a series of dots or marks, each of which represents a fraction of a second, the line of dots or marks extending substantially parallel to the general direction of the wave chart described by the light beam 37. This may be readily accomplishing by providing a disc 44 having a plurality of openings 45 therein adapted to be rotated in the path of a secondary light beam 46 emanating from the light source 36. The light beam 46 passing through the openings of the disc 44 may be projected upon the same sensitized strip 39 to describe a series of marks thereon, one for each of the openings 45. One of the openings 45a is preferably larger than the remainder so that upon each revolution of the disc 44 a distinguishing mark will be produced. Thus by providing ten openings 45, a series of marks 48a may be produced upon the record strip 39 representing ten equal divisions. The tenth mark being produced by the large opening 45a is of greater length or of greater size or in some other manner distinct from the remaining nine marks. By providing the disc 44 with any suitable time mechanism such as a synchronous motor 47, the marks produced upon the charts will represent lapse of time; for example, each mark representing $\frac{1}{10}$ of a second while the space between the distinct marks will represent lapses of one second each.

Due to the fact that the depth of wells varies considerably and, further, due to the fact that conditions of obstruction or constriction of the space between the well casing 2 and the tubing string 5 varies considerably in different wells, the same pressure differential cannot be used successfully in all wells and it is necessary to vary the pressure impulse through considerably wide limits, dependent upon the conditions encountered at a particular well. For this reason I prefer to direct a portion of the beam 37 upon the ground glass screen 38 so that by firing one charge of gas pressure into the well and observing the path described by the light beam, a determination of whether or not the correct pressure impulse is being used may be made. For example, one pressure impulse which is estimated to be correct for a given well may not produce a sufficient fluctuation in the echo waves received from the tubing catcher and the fluid surface, and a higher pressure or greater quantity of gas must be used in order to create the desired impulse. Thus by observing the effect of a succession of pressure impulses liberated into the well, the person making the survey will be able to determine which of the echoes rebounds from the tubing catcher and which of the echoes rebounds from the fluid surface.

The pressure wave velocity in different wells varying through wide limits, it is desirable to provide some regulation controlling the sensitivity of response of the diaphragm 23 to pressure variations and also to control the sensitivity of the diaphragm to distinguish between echoes from different obstructions in the well. In some surveys it may be desirable to render this diaphragm more sensitive than in making surveys of other wells under other conditions, particularly for the purpose of allowing the amplitude of movement of the light beam in response to collar echoes to be substantially the same in the surveying of different wells, and I provide a ready means for varying the sensitivity of response of the diaphragm 23 by providing in the pressure chamber 22 two distinct chambers or compartments. One of these compartments or chambers 48 may be formed centrally of the diaphragm chamber 22 as by providing an annular division wall 49, the chamber 48 being disposed on the forward side of the diaphragm 23 and constituting a chamber of fixed volume. The second of these chambers 50 may be provided between the annular wall 49 and the exterior wall of the diaphragm chamber 22, the volume of this chamber being relatively great as compared with the volume of chamber 48. By providing an orifice 51 in the wall 49 intercommunicating chambers 48 and 50 and providing a valve 52 for regulating the effective size of this orifice, the effective volume of the chamber communicating with the forward face of the diaphragm 23 may be varied in small increments so that the diaphragm 23 may be so regulated as to respond with varying degrees of sensitivity.

The typical desired configuration of the path described by the light beam 37 is indicated in Fig. 2 wherein *a* represents the path described by the light beam as a result of the pressure wave created by a discharge of gas from the chamber 12 into the well casing. From an inspection of the line *a*, it will be noted that this line is a relatively straight but somewhat wavy line, having distinct peaks at *b*, *c* and *d*. The peak *b* is that which will be produced by the deflection of the diaphragm 23 when the impulse of gas from the chamber 12 is liberated into the casing 2. At a predetermined time thereafter, dependent upon the velocity of the wave in the particular well, a peak *c* will be produced as a reflection from the tubing catcher 9, while at a predetermined time thereafter an additional peak or series of peaks will be produced at *d* as a reflection of the wave from the fluid surface.

Thus by observing the effects of a series of pressure impulses of different intensity or pressure, the operator may determine which impulse is most desirable to produce the distinctly recognizable and differentiatable peaks *c* and *d*, allowing him to differentiate between echo from the tubing catcher and the echo from the fluid surface. As hereinbefore stated, knowing the depth or location of the tubing catcher 9, the comparison of the elapsed time between the peaks *b* and *c* and the elapsed time between the peaks *b* and *d*, an accurate determination of the fluid level may be produced.

After the most desirable pressure impulse has been determined, the motor 41 may be set into action and a permanent record of the path described by the light beam may be made upon the sensitized film 39 with assurance that the various peaks *b*, *c* and *d* will be readily distinguishable upon the diagram so produced.

As will be observed from an inspection of Fig. 2, the diagram on the strip 39 also shows the plurality of spaced dots or other means of indicating elapsed time, such series of dots being indicated at 48a.

Having made a diagram as indicated in Fig. 2, a direct measure and determination of the fluid depth may be achieved. Also it will be observed that by selecting impulses of the desired magnitude, reflections from other obstructions in the well may be noted and recorded, thus assisting in the location and determination of other re-

strictions as well as a measurement of the fluid level.

For example, each of the collars 18 of the tubing string will produce a distinct echo differentiable from the echoes from other sources. This allows the accurate measurement of the fluid level in a well where, by reason of failure to keep records or loss of records, the location of the tubing catcher is not known or wherein the catcher is submerged or is omitted. For example, in some wells tubing has been drawn out and replaced by other tubing and no record has been made of the lengths of tubing drawn out or the lengths of each section drawn out or the lengths or number of tubing section employed to replace them so that to merely compare the time distance between the peaks *b* and *c* would not give a true indication of the velocity of the wave in the particular well. However, if it is reasonably assured that each of the tubing lengths is approximately the same, and the usual practice in oil wells is to employ tubing lengths in a given well, all of which are the same, an indication of the number of tubing lengths located within any given well, multiplied by the average length of a tubing section, will give a true measure of the location of the tubing catcher or the location of the pump or other device which constitutes an obstruction in the well. Thus, for example, by selecting a desired pressure impulse, by comparison of a succession of pressure impulses and the waves produced thereby, upon the ground glass 38, a wave or line of the character indicated at *a* in Fig. 3 may be produced wherein, though *a* is still wavy, it is produced by a series of peaks *e*. By counting the number of these peaks, each of which represents a reflection back from a collar 18, the number of lengths of tubing between the peaks *b*, *c* and *d* may be determined.

However, in actual practice there are so many other possible disturbances in the well as to create peaks similar to *e* which are not readily distinguishable therefrom and I prefer to provide a means for tuning out other vibrations, harmonics or other disturbances so that the peaks *e* will accurately represent only reflections from the collars 18.

As will be understood, the introduction into a sound wave or multiplicity of sound waves of another wave tuned with one of the waves, produces a beat or amplification of certain of these waves differing in frequency from the first wave will be damped out. By selecting the correct length for the pipe 18, that is, by selecting the correct distance between the casing 2 and the diaphragm 23, a tuned wave may be produced which will effect the movements of the diaphragm 23. Since it is desired to count the number of tubing collars, all that is necessary is to lengthen or shorten the pipe 18 until it is tuned to one of the harmonics of the impulses or echoes produced by the collars 18. From experience it has been found that selection of the pipe 18 of approximately one-third of the length of a section or joint of the tubing 9, a third harmonic is is produced which beats with the impulses echoed from the tube collars 18 to produce magnified or amplified peaks *e* and permits the ready distinguishing of the impulses produced by the collars 18 from other impulses.

I prefer, however, to employ in the length of the pipe 18 an adjustable coupling 19 which allows the accurate lengthening or shortening of the pipe 18 until, by observing the path of the light beam upon the ground glass 38, a distinct pattern is made represented by the line *a* on Fig. 4, in which each of the intermediate peaks *e* is amplified as indicated in Fig. 4 so that it is readily recognizable.

The adjustment of the coupling 19 should be made until, with a given pressure impulse, a uniform deflection of the mirror 36, that is, a uniform amplitude of the peaks *e*, is achieved, and by observing this upon the ground glass 38 the operator will note when the pipe 18 is of such length as to be "tuned" with the tubing lengths.

Thus, even though the location of the tubing catcher is not known, if the average length of tubing section is known, the production upon the strip 39 of a diagram such as shown in Fig. 4 allows the counting of each of the collars 18 and a clear understandable record is made of the length of tubing string between the impulses *b*, *c* and *d*, permitting the quick and accurate location and determination of the exact level of the fluid in the well.

Where the tubing lengths are not known and where the location of the tubing catcher is not known, or where the catcher and liner top are submerged, a quick and ready method of determining the velocity of the pressure wave through the particular gaseous medium encountered in a particular well may be made by employing an elongated tube or pipe 83 coupled as by means of a short pipe 84 to the pipe 18 and controlled by a valve 85 in such manner as to permit gas from the casing 1 to flow through the pipe or tube 83, thus providing in the pipe 83 an atmosphere corresponding to the atmosphere or gaseous medium in the casing 1. An open exhaust pipe 86 leads from the opposite end of pipe 83 open to the atmosphere or connected to a gas flow line so that the pressure within the pipe or tube 83 will remain substantially constant as of the value of the gas in the casing 1. Near one end of the tube 83, a diaphragm 87 may be provided and arranged to be vibrated at any desired frequency as by coupling the diaphragm 87 by a pipe 88 open to the atmosphere at 88a, to a source of fluid pressure, such as compressed air, indicated at 89. A rotary valve 90 is interposed in the pipe 88 and arranged to be driven by means of a variable speed motor 91 regulated as to speed by means of a variable speed motor 91 regulated as to speed by means of a suitable rheostat or other controlling device 92 so that by rotating the motor 91 at any speed a series of pressure impulses will be created in the pipe 88, and will beat upon diaphragm 87 to create a pressure wave in the tube or pipe 83 of known frequency, the frequency being variable by varying the speed of motor 91.

At the opposite end of the pipe 83 I couple a pressure responsive device which may be constructed in the same manner as the diaphragm chamber 22 and diaphragm 23 hereinbefore described. This pressure responsive device is illustrated at 93 coupled directly to the end of the pipe 83, the diaphragm 94 of which receives the impulses transmitted through the pipe 83 to vibrate in response thereto and to move a mirror 95 in the same manner as was described with reference to the mirror 36. The mirror 95 reflects a light beam from a suitable source 96 upon a polygon of mirrors 97 revolved by means of an adjustable speed motor 97a at a speed synchronous with the speed of the motor 91 so that the amplitude and uniformity of the vibrations of the diaphragm 94 may be visibly observed.

As is well known in the art, each gaseous medium, variable as to density, temperature, etc., is resonant to pressure waves or sound waves of predetermined frequency. Thus by varying the speed of operation of the motor 61 until the pressure impulse created by the diaphragm 57 makes one round trip (or multiple thereof) to the diaphragm 64 and back to the diaphragm 57 in time to just synchronize with the next impulse created by the diaphragm 57, the pattern described by the beam of light on the mirrors 67 will show uniform amplitude, and noting the frequency of the impulses produced upon the diaphragm 57 (that is, noting the speed of the motor 61) the velocity of the sound through this particular gaseous medium may be readily determined by comparing this frequency with the frequency at which resonance is achieved at the pipe 53 with air in it.

It will therefore be observed that I have provided a method of determining the location of obstructions in wells and accurately locating and measuring the fluid level in a well without the necessity of removing any of the apparatus from the well, the entire measurement and determination being accomplished in a relatively short time.

It will be understood by those skilled in the art that the creation of pressure impulses within the well may be accomplished by decreasing the pressure in the well instead of admitting a charge of gas from the pressure tube 12 into the well. For example, if the pressure in the well is relatively high, the valve 14 in the pressure chamber may be closed and the valve 16 opened, allowing the pressure in the well to build up within the impulse chamber 12. Then by operating valve 14, allowing the pressure within the chamber 12 to rapidly discharge, a pressure impulse may be created within the well which acts in the same manner as hereinbefore described for the introduction of pressure from the tank or other source 11.

It will also be understood that if desired special constrictions may be placed in the well for future measurements of the fluid level therein to take the place of the tubing catcher 8. Such constrictions could comprise a closed cylinder of pipe surrounding and attached to one of the tubing sections when the tubing is run into the well and by noting and recording the location of such constriction, the future measurements of the fluid level by my pressure impulse method can be readily determined, employing the reflection of the wave from the restricting member in place of the reflection from a tubing catcher 8 or other restriction in the well.

While I have shown and described the preferred embodiment of my invention, I do not desire to be limited to any of the details of construction shown or described herein, except as defined in the appended claims.

I claim:

1. In an apparatus for determining the location of an obstruction in a well having therein a string of assembled tubing sections interconnected with each other by coupling collars, means communicating with said well for creating a pressure impulse in said well, echo receiving means including a pressure responsive device exposed to said well for receiving pressure impulses from the well and for measuring the lapse of time between the creation of the impulse and the arrival at said receiving means of the echo from said obstruction, and means associated with said pressure responsive device for tuning said receiving means to the frequency of echoes from the tubing collars of said tubing sections to clearly distinguish the echoes from said couplings from each other.

2. In an apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure responsive device for receiving pressure impulses from the well, a pipe coupling said pressure responsive device to the well, means for adjusting the effective length of said pipe to tune said pressure responsive device to one of the harmonics of echoes of said impulse received from the coupling collars of said tubing string, and means for measuring the frequency of said tubing collar echoes and for measuring the lapse of time between the creation of said impulse and the arrival at the pressure responsive device of the echo of said impulse from said obstruction.

3. In an apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure responsive device for receiving pressure impulses from the well, a pipe coupling said pressure responsive device to the well, means for adjusting the effective length of said pipe to tune said pressure responsive device to one of the harmonics of echoes of said impulse received from the coupling collars of said tubing string, and means associated with said pressure responsive device for measuring the frequency of said tubing collar echoes and for counting the same and for measuring the lapse of time between the creation of said impulse and the arrival at the pressure responsive device of the echo of said impulse from said obstruction.

4. In an apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure responsive device for receiving pressure impulses from the well, a means intercoupling said pressure responsive device with the well and having such effective length as to tune said pressure responsive device to one of the harmonics of echoes of said impulse received from the coupling collars of said tubing string, and means associated with said pressure responsive device for measuring the frequency of said tubing collar echoes and for counting the same and for measuring the lapse of time between the creation of said impulse and the arrival at the pressure responsive device of the echo of the impulse from said obstruction.

5. In an apparatus for determining the location of an obstruction in a well, means communicating with said well for creating a pressure impulse in the well, a pressure responsive device including diaphragm means, means coupling said diaphragm means to said well to allow the pressure of said well to press upon one face of said diaphragm means, means communicating between said coupling means and the opposite face of said diaphragm means for equalizing the static pressure on both sides of said diaphragm means whereby said diaphragm means will move in accordance with variation in pressure within said well, and means for measuring the lapse of time between the creation of said pressure impulse and the movement of said diaphragm means by the echo of said impulse from said obstruction.

8. In an apparatus for determining the location of an obstruction in a well, means communicating with said well for creating a pressure impulse in the well, a pressure responsive device including diaphragm means, means coupling said diaphragm means to said well to allow the pressure of said well to press upon one face of said diaphragm means, means defining a restricted by-pass intercommunicating the opposite face of said diaphragm means with said coupling means to equalize the static pressure on both faces of said diaphragm means whereby said diaphragm means will move in accordance with variation in pressure within said well, and means for measuring the lapse of time between the creation of said pressure impulse and the movement of said diaphragm means by the echo of said impulse from said obstruction.

7. In a device for determining the location of an obstruction in a well, means communicating with said well for creating a pressure impulse in said well, means for receiving and translating echoes received from said obstruction including diaphragm means, coupling means intercommunicating one face of said diaphragm means with said well, means defining a pressure equalising chamber on the opposite face of said diaphragm, means defining a second chamber of greater volume communicating with said first chamber, valve means for restricting communication between said two chambers to vary the effective volume of the chamber exposed to said opposite face of said diaphragm means to control the sensitivity of response of said diaphragm means to pressure variation in said well, and means for measuring the lapse of time between the creation of said impulse and the movement of said diaphragm by the echo of said impulse from said obstruction.

8. In a device for measuring pressure waves in a fluid medium under static pressure, a diaphragm, a pressure-tight housing surrounding said diaphragm and having a window therein capable of passing light between the interior and exterior of the housing, said housing being divided by the diaphragm into two compartments, one on each side of the diaphragm, a medium entrance communicating with one compartment to directly expose one face of the diaphragm to the medium, a by-pass extending between the compartments to equalise the static pressure of the medium on opposite faces of the diaphragm, light-reflecting means associated with the diaphragm, means for directing a light beam upon said reflecting means to reflect the beam through said window, and means disposed exteriorly of said housing for receiving and translating the reflected beam.

9. In a device for measuring pressure waves in a fluid medium under static pressure, a diaphragm, a pressure-tight housing surrounding said diaphragm and having a window therein capable of passing light between the interior and exterior of the housing, said housing being divided by the diaphragm into two compartments, one on each side of the diaphragm, a medium entrance communicating with one compartment to directly expose one face of the diaphragm to the medium, a by-pass extending between the compartments to equalise the static pressure of the medium on opposite faces of the diaphragm, light-reflecting means associated with the diaphragm, means disposed exteriorly of the housing for directing a light beam through said window to strike said reflecting means and to be reflected thereby back through said window, and means disposed exteriorly of said housing for receiving and translating the reflected beam.

10. In a device for measuring pressure waves in a fluid medium under static pressure, a diaphragm, a pressure-tight housing surrounding said diaphragm and having a window therein capable of passing light between the interior and exterior of the housing, said housing being divided by the diaphragm into two compartments, one on each side of the diaphragm, a medium entrance communicating with one compartment to directly expose one face of the diaphragm to the medium, a by-pass extending between the compartments to equalise the static pressure of the medium on opposite faces of the diaphragm, light-reflecting means associated with the diaphragm, means for directing a light beam upon said reflecting means to reflect the beam through said window, means disposed exteriorly of said housing for receiving and translating the reflected beam, and means extending into said housing to adjust the position of said reflecting means to adjustably direct the reflected beam upon said receiving means.

11. In a device for measuring pressure waves in a fluid medium under static pressure, a diaphragm, a pressure-tight housing surrounding said diaphragm and having a window therein capable of passing light between the interior and exterior of the housing, said housing being divided by the diaphragm into two compartments, one on each side of the diaphragm, a medium entrance communicating with one compartment to directly expose one face of the diaphragm to the medium, a by-pass extending between the compartments to equalise the static pressure of the medium on opposite faces of the diaphragm, a light reflector associated with said diaphragm, means pivoting said reflector within the housing, means connecting said diaphragm and said reflector to move said reflector about its pivot in accordance with deflections of said diaphragm, means for projecting a beam of light upon said reflecting means to reflect said beam through said window, means disposed exteriorly of said housing for receiving and translating the reflected beam, and handle means projecting through said housing and accessible exteriorly thereof for adjusting said reflector pivot means to adjustably direct the reflected beam upon the receiving means.

12. In an apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure responsive device for receiving pressure impulses from the well, means coupling said pressure responsive device to the well to expose said device to pressure variations existing in said well and having a length approximately a multiple of the length of a tubing section to tune said device to the frequency of the echoes of the impulse received from the couplings of the tubing string, and means associated with said device for recording the echoes from the tubing couplings and from said obstruction to permit counting the coupling echoes between the creation of the impulse and the echo from the unknown obstruction to determine its location.

13. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating

with said well for creating a pressure impulse in said well to produce echoes of said impulse from the couplings and other obstructions in said well, echo receiving and registering means coupled to said well to expose said receiving and registering means to pressure variations produced in said well by echoes from said obstructions, and means associated with said receiving and registering means to accent the registration of tubing coupling echoes.

14. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from couplings and other obstructions in said well, pressure responsive echo receiving and registering means coupled to said well to expose said receiving and registering means to pressure variations in said well produced by echoes from said obstructions, and interference eliminating means associated with said receiving and registering means for limiting the response of said receiving and registering means to the registration of echoes from actual obstructions in the well whereby the registered echoes of the tubing couplings may be readily distinguished from each other and from the echoes from other actual obstructions in the well.

15. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from the couplings and other obstructions in said well, pressure responsive echo receiving and registering means coupled to said well to expose said receiving and registering means to the pressure variations produced in said well by echoes from said obstructions, and resonance means associated with said receiving and registering means to produce therein a natural acoustical period of oscillation so related to the frequency of the echoes from the tubing couplings as to accent the registration of the tubing coupling echoes.

16. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating therein a pressure impulse to produce echoes of said impulse from the couplings and other obstructions in the well, echo receiving and registering means including a pressure responsive device, and pipe means coupling said pressure responsive device to said well to expose said device to pressure variations in the well, and means for adjusting the effective length of said pipe means to produce a natural acoustical period of oscillation of said pressure responsive device so related to the frequency of the echoes of said tubing couplings as to accent the registration of said echoes.

17. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating therein a pressure impulse to produce echoes of said impulse from the couplings and other obstructions in said well, pressure responsive echo receiving and registering means having a natural frequency of oscillation so related to the frequency of the echoes from said tubing couplings as to accent the registration of said echoes, and means interconnecting said receiving and registering means to said well to expose said receiving and registering means to pressure variations in said well.

CRANFORD P. WALKER.

PLAINTIFFS' EXHIBIT No. 2

Walker Reissue Patent No. 21,383

[Endorsed]: Filed Oct. 6, 1943.

600

March 5, 1940. C. P. WALKER Re. 21,383

METHOD OF DETERMINING FLUID DENSITY, FLUID PRESSURE, AND THE PRODUCTION CAPACITY OF OIL WELLS

Original Filed Oct. 26, 1937

FIG. 1.

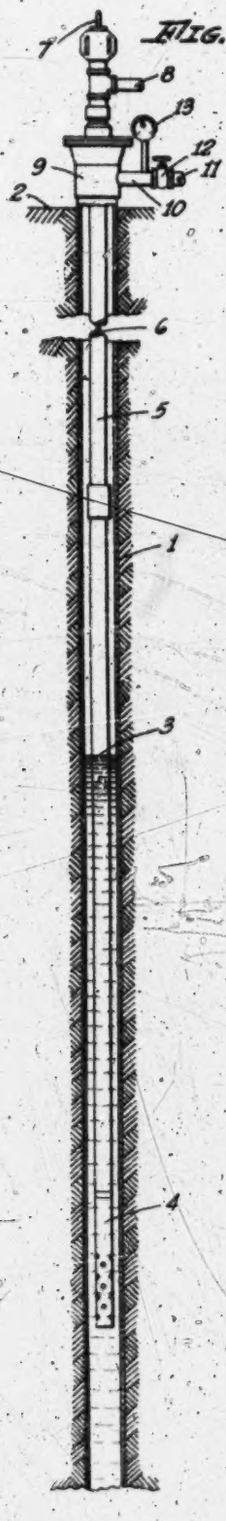


FIG. 2.

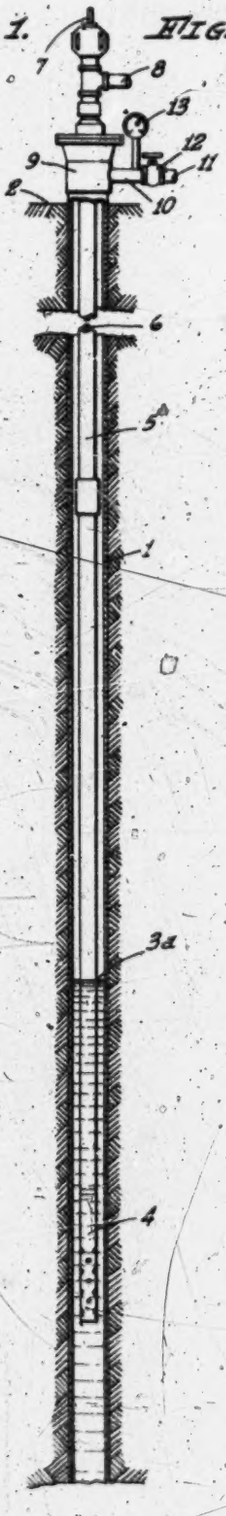
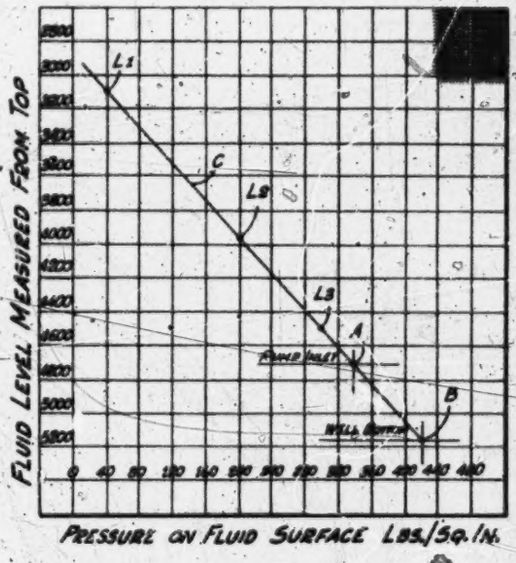


FIG. 3.



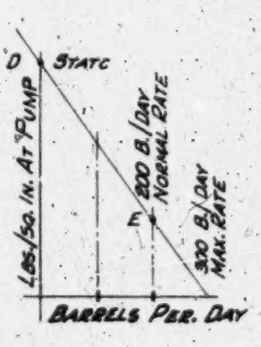


FIG. 4.

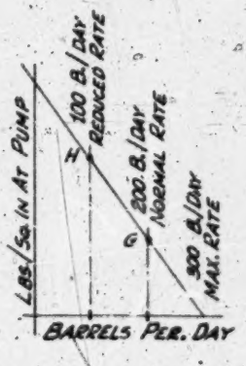


FIG. 5.

INVENTOR.
CRANFORD P. WALKER
BY Harold W. Mattingly
ATTORNEY.

Reissued Mar. 5, 1940

Re. 21,383

UNITED STATES PATENT OFFICE

21,383.

METHOD OF DETERMINING FLUID DENSITY, FLUID PRESSURE, AND THE PRODUCTION CAPACITY OF OIL WELLS

Cranford P. Walker, San Marino, Calif.

Original No. 2,161,733, dated June 6, 1939, Serial No. 268,895, April 19, 1939, which is a continuation of Serial No. 171,170, October 26, 1937. Application for reissue December 4, 1939, Serial No. 307,551

11 Claims. (Cl. 73—51)

My invention relates to methods of determining the fluid density, fluid pressure and potential production capacity of oil wells and has particular reference to methods of determining the most desirable character of pumping equipment and manner of operating the same to permit an efficient production of oil from a given well.

This application is a continuation of my copending application Serial No. 171,170, filed October 26, 1937.

It is the common practice in oil well production activity to permit an oil well to produce as a flowing well, that is, to permit the oil to flow out at the ground surface due to the pressure in the oil formations, until the production rate reaches a considerably low value or ceases, after which gas lifting is usually attempted and continued until the production rate with gas lifting reaches a relatively low value or the production entirely ceases. At this time, and in some instances prior to any attempt to gas lift the oil, mechanical pumping devices are usually installed to lift the oil by mechanical means to the surface, these pumps usually comprising a pump barrel located at a considerable depth in the well, usually 50 to 150 feet below the surface of the well fluid in the well while it is producing, plungers or other reciprocating devices being employed in the barrel and operated from the ground surface by means of sucker rods.

Usually the selection of the size and character of the pumping equipment is determined by the production of the well during its flowing or gas lifting life by estimating from this production the type or character of pump which appears to be most suitable. In many fields, however, the type, size and character of the pump installed is usually one determined as "standard" for that particular type of well in the particular field. In other words it is one having the same dimensions as pumps in other wells producing from the same horizon. Frequently, such well receives no further attention until the field as a whole has declined to a point where it becomes necessary to increase the production from the wells, as for example, by the encroachment of water, necessitating the lifting of greater quantities of liquid in order to obtain the desired amount of oil. When this condition occurs, it is customary to increase the capacity of the pumping equipment.

Also, the production from a given well may be believed to be less than the character of the well and the character of the pumping equipment employed should indicate, as for example, the pump may be operating at a relatively low volumetric efficiency. As is well understood, the column of well fluid extending up into the well bore is a mixture of dense oil and gas entrained therewith and the maximum volumetric efficiency of the conventional pumping equipment is attained when the pump inlet is located along this column at such place as will permit a maximum amount of dense liquid to flow into the pump upon each stroke. Thus if the pressure in the column at any point below the surface of the column can be determined, the pump inlet may be so properly located as to allow it to take in a minimum quantity of gas upon each stroke. At this point it should be noted that wherever in the following description the expression "fluid", "fluid surface", "fluid level", are used, the word "fluid" is intended to refer to the natural well fluid which comprises a mechanical mixture of dense liquid, (either oil or oil and water) with such quantities of gas entrained therein as may be present in the particular well under consideration.

In order to determine whether or not any change in the size, character, operating characteristics or location of the pumping apparatus should be made, it is desirable that the location of the fluid surface, the character of the fluid in the well, its density and the fluid pressure exerted at any given point below the surface of the fluid and the maximum potential production capacity of the well should be determined. For example, if the pumps in a particular field are operating at good volumetric efficiency, much can be determined from the quantity of oil produced and the volumetric displacement per stroke of the pump, and if the pumps are operating at their maximum capacity, the fact that the fluid level is at a considerable distance above the pump inlet may indicate that the operator is justified in making a change in the size or character of the pumping equipment. Again, if the volumetric efficiency of the pump is found to be low, as for example, when the pump appears to be taking in a comparatively large quantity of gas upon each stroke of the pump, the operator should know whether or not the inlet of the pump is located at a point too near the fluid surface to that he may determine how far below the fluid surface he should lower the pump in order to allow it to receive dense fluid for the full stroke.

Frequently in wells where the quantity of gas produced by the well is relatively small, an increased production of the pump may be ob-

tained by raising the pump to a point nearer the fluid surface so that a better separation of the gas takes place prior to the entry of the fluid into the pump, while if the well is making a large quantity of gas, it may be better to lower the pump to a point below where free gas enters the well bore, if this is possible, so that upon each stroke of the pump, dense liquid will be picked up. However, in many instances, it is dangerous to lower the pump too close to the bottom as sand is likely to be pumped into and foul the pump.

In wells where the fluid level is so low that the pump is not completely submerged and hence does not receive a full cylinder, or barrel of fluid upon each stroke, a pounding at the pump is created which may be heard or determined at the ground surface. This same character of pounding, however, may be produced by the pump even though the fluid surface is at a considerable distance above the pump inlet, occasioned by the inflow into the pump of large quantities of free gas. Hence, simple tests to determine the fluid level relative to the pump inlet will show which of these two conditions exists but will not produce the desired information to the operator as to the desirable character or location of the pumping mechanism.

If, however, the fluid pressure at different levels below the surface of the fluid is determined, this information may be employed to determine the most desirable location of the pump and whether or not a change should be made in the size, operating characteristics or character of the pumping equipment employed in a given well to produce an increased or maximum production from the well.

The determination of the fluid pressure at different points below the surface of the well fluid may be determined by instruments known as pressure recorders, which must be either attached to the pump or lowered into the well to the desired level, or must be lowered into the well on wires, cables or other supporting devices and left at the desired levels for a predetermined length of time necessary to permit the recorders to make a chart or record of the pressures encountered. All of these methods, however, required the stopping of the pumps and the stopping of production while the test is being made and further required the removal of the pumps and sucker rods and sometimes the tubing and other apparatus from the well in order to insert the pressure recorders or pressure measuring devices, which entailed considerable labor and time and held up the production of the well for a considerable period of time.

It is therefore an object of my invention to provide methods for determining the fluid pressure at any given point below the surface of the column of well fluid which extends up into the space between the casing and the pump tubing (known as the "standing column"), determining the density of the fluid in such column and the production index of the well without interrupting or interfering with the production of the well by the usual pumping apparatus employed therein.

Another object of my invention is to provide a ready means for determining the fluid pressure at any level below the surface of the standing column of fluid in the well and for determining the density of the well fluid in any particular well without necessitating the removal or replacement of any of the usual pumping apparatus, flow tubes, sucker rods or other mechanism found in a well being produced by a mechanical pump.

Another object of my invention is to provide information to aid in the determining of the proper location of the pump in an oil well to achieve the maximum volumetric efficiency of the pump in handling the particular character of well fluid found in the particular well.

Another object of my invention is to provide a ready method for determining the potential production capacity of an oil well with a minimum of expense, delay or interruption of the production activities of the well.

Another object of my invention is to provide a method of determining the density of the fluid in a well by measuring the amount of recession of the level of the fluid surface under two or more conditions of pressure upon the fluid surface and computing from the facts thus obtained the density of the fluid in the well. Fluid densities in producing wells range all the way from less than .04 pound per square inch to over .4 pound per square inch per foot of fluid in the well. Therefore, a simple fluid level determination without a density or pressure determination gives very little information.

Another object of my invention is to provide a ready method for determining the potential production capacity of a well by measuring the pressure at the pump inlet under two conditions of operation of the pump and computing therefrom the maximum potential production obtainable from the well.

Another object of my invention is to provide a ready method for determining the potential production capacity of a well by determining the fluid pressure at some point below the fluid surface in the well, either at the pump inlet or any other location, under two conditions of production from the well (one of which may be zero production), and by comparing the pressures so determined with the production rates, determining the maximum potential production obtainable from the well.

Other objects of my invention will be apparent from a study of the following specification read in connection with the accompanying drawing, wherein

Fig. 1 is a diagrammatic, cross-sectional view of a typical oil well, illustrating the level of the fluid surface as being located a considerable distance above the inlet of the pumping apparatus employed;

Fig. 2 is a view similar to Fig. 1 but illustrating the effect on the fluid surface of gas pressure allowed to build up in the casing;

Fig. 3 is a diagrammatic view illustrating a chart or graph which may be employed in the practice of my method for the computation of fluid density and pressures at different locations or levels within the well;

Fig. 4 is a diagrammatic view illustrating a chart or graph which may be employed to compute the maximum potential capacity of a well from a comparison of the pressure at the pump while it is idle with the pressure at the pump while it is operating normally; and

Fig. 5 is a view similar to Fig. 4 illustrating the manner in which a more accurate computation of the potential capacity of a well may be obtained by comparing the pressure at the pump under two production rates of the pumping apparatus.

Referring to the drawing, I have illustrated

Fig. 1 a typical oil well which includes a casg 1 extending down through the well bore from e ground surface 2 into the oil producing sands, e oil flowing from the sands or oil formation to the casing and rising in the casing to some vel indicated at 3. Pumping apparatus emloyed to remove the oil from the well usually ncludes a suitable pump 4 located upon tubing ring 5, constituting the flow tubing through hich the oil is raised to the ground surface, ne pump 4 including usually some reciprocatng mechanism operated by reciprocal movements of a string of sucker rods 6 extending own through the tubing 5 and connected to reciprocating power apparatus at the ground surface, as indicated at 7. The flow tubing 5 is provided with an outlet 8 communicating with a uitable oil line through which the oil pumped rom the well is conveyed to any desired location.

The casing 1 is closed at its upper end as indicated at 9, an outlet 10 being provided communicating with the casing 1 to permit gas escaping from the oil to pass into a suitable gas line 11, a control valve 12 being usually provided to control the flow of gas into the gas line.

By properly selecting the size, the stroke and the speed of the pump 4, the pump may be made to remove the oil from the well at approximately the same rate at which the oil flows into the well from the surrounding formation, and if so selected, the well will be operated at its maximum capacity. However, oil coming from the formation contains relatively large quantities of gas which, due to the pressure of the oil, cannot readily escape and is drawn into the pump with the oil, thereby reducing the liquid volumetric efficiency of the pump.

I have discovered a ready means for ascertaining the pressure existing at the pump entrance or at any other point below the surface of the standing column of well fluid in any given well without requiring the removal of the pump or any of its parts, and I have also discovered a ready method for determining the density of the well fluid, the information so obtained being used to select the location of the pump at the most desirable level and for use in determining the production capacity of the well.

To obtain the information required, I measure or determine the stable location of the fluid surface of the "standing column" of fluid within the well when the pump is operating at its normal production capacity and with the pressure of gas within the casing at the usual or normal value maintained during the usual or normal pumping operations at the well. The expression "standing column" as used herein is intended to mean the column of well fluid which stands in the well as distinguished from the pumped liquid column which is being lifted to the ground surface by the pump, such standing column being known in the oil industry as the "dead" fluid column, and with the usual type of pumping apparatus this standing column lies in the annular space between the tubing 5 and the casing 1.

This location of the fluid level may be readily accomplished by employing the methods and apparatus disclosed in United States Letters Patent No. 2,047,974, issued to Harold T. Wyatt and Paul E. Lehr, July 21, 1936, and in United States Letters Patent No. 2,156,519, issued to me on May 2, 1939, and in my copending application Serial No. 164,534, filed September 18, 1937. While the methods and apparatus are completely disclosed in the said patents and application, the method may be stated briefly as including the introduction into the annular space between the tubing 5 and the well casing of a sudden change in pressure in the well casing and measuring the length of time elapsing between the production of this pressure impulse and the return to the ground surface of the echo thereof from the surface of the fluid. Noting the distance from the ground surface of the fluid level under these conditions and noting the pressure of gas at the casing head, as by means of a pressure gage 13, the pressure on the fluid surface may be computed as follows: To the casing head pressure is added the effect of pressure on the fluid surface exerted by the weight of the column of gas between the fluid surface and the casing head. A gravity test may be made of the gas at the casing head which will determine the pressure exerted by each foot or hundred feet of height of the gas column. This information may be computed by the following formula which is by Dice:

$$\text{Log}_{10} Pb = \frac{SD}{122.827T} + \text{Log}_{10} Pt$$

Where

Pb=Lbs./sq. in. absolute at bottom of gas column.
Pt=Lbs./sq. in. absolute at top of gas column.
S=Specific gravity of the gas (air is considered 1).
D=Depth from casing head to fluid surface.
T=Mean temp. of the gas column in degrees R. absolute.

This information may then be plotted upon a graph or chart as illustrated in Fig. 3 in which the conditions existing in the particular well under measurement are assumed to be such that with a pressure of 36 pounds per square inch at the casing head, the fluid surface is found to lie at 3100 feet below the casing head. The specific gravity of the gas in this instance may be found to be such that the effect will be to produce 4 pounds per square inch pressure on the fluid surface. Thus, the addition of 36 pounds and 4 pounds produces a total pressure on the fluid surface of 40 pounds per square inch. By arranging the chart shown in Fig. 3 with the ordinates representing the fluid level measured from the ground surface and the abscissae representing pressure on the fluid surface in pounds per square inch, the point L1 determined from the preceding formula may be plotted on the chart shown in Fig. 3.

Now the valve 12 is closed or a suitable pressure regulator is placed in the gas line 11 and the pressure within the casing is allowed to build up to any predetermined value. As the pressure builds up, the fluid level 3 tends to recede, the pump drawing down the fluid column until a stable condition of production and fluid level is reached under the new gas pressure. By continuing the operations of the pump during the building up of this pressure, preferably for a period substantially equal to three times the length of time required for the pump to remove the column of fluid between the original fluid level and a new fluid level to which the pressure depresses the fluid surface, represented at 3a (Fig. 2), a stable condition will be achieved at which the fluid level will become constant and the production by the pump will be approximately the same as before the pressure was allowed to build up in the casing. When this stable condition is reached, a second measurement of the fluid level is obtained by the level measuring methods and apparatus hereinbefore described.

Having determined the new location of the fluid surface, the pressure exerted thereon may now be calculated as follows: Assuming that the casing head pressure in this instance was adjusted to 170 pounds, to this should be added the pressure due to the weight of the column of gas above the new fluid level. The determination of the effect of the weight of the column of gas upon the fluid level may be obtained either by calculation or may be plotted out and obtained from suitable charts prepared for this purpose. In this instance, it may be assumed that the pressure due to the gas column is 30 pounds per square inch, making a total of 200 pounds per square inch on the fluid surface. Now, assuming that the level to which the standing column of fluid has receded is 3966 feet from the top of the well, the new point L2 on the chart shown in Fig. 3 representing the new level and the pressure on the fluid surface may be placed upon the chart.

From an exhaustive series of actual tests I have discovered that in any given well which is being produced by a mechanical pump and where the cross sectional area of the standing fluid column is constant, there is a constant relation between a change in the pressure upon the fluid surface and the corresponding change in the location of the stable fluid surface for any given rate of production. This result follows from the fact, as I have discovered, that even though large quantities of gas bubbles are usually flowing vertically through the fluid column in a pumping well, the density of the gas and oil mixture in the column is constant throughout the height of the column. This is contrary to the usual concept of the fluid density in producing oil wells as heretofore it has been possible to explore, usually with a pressure recorder, the density of the fluid in flowing wells only. These measurements are usually made in the flowing column of fluid where, on account of gas breaking out of the liquid as it flows up to regions of lower pressure, the fluid density is found to increase with the depth to which the pressure recorder is run in the column. Under equilibrium conditions in wells being produced by mechanical pumps there is evidently very little gas liberated from the liquid in the standing column, therefore the volume of gas which enters the column at the bottom is practically the same as that given off at the top. The constant density phenomena which I have discovered appears to be due to the fact that the size of the gas bubbles decreases, and their density increases with their depth in the fluid column. They therefore travel much slower near the bottom than they do near the top of the fluid column where they are large and light. At the bottom therefore there are many small heavy gas bubbles traveling close together vertically upward at a slow rate whereas as these same bubbles approach the top of the column they become very large and light and travel at a high speed and are farther apart. The relations of bubble size, weight and velocity at different levels in the fluid column are evidently such that the proportions of gas and liquid are constant throughout the height of the column and the density does not change.

It follows therefore that an increase in pressure on the surface of the fluid column will cause the column to recede through a distance directly proportional to the increase in pressure. Hence a line drawn on the chart shown in Fig. 3 intersecting the points L1 and L2 will truly represent the fluid level at any of the pressures which may be placed upon the column. Thus by merely extending the line C downwardly on the chart until it crosses the ordinate representing the location of the pump inlet indicated on the chart as A, a direct reading may be made from the chart of the pressure on the fluid surface which would be required to cause the surface of the column to recede to the pump inlet. On the chart this is represented as 336 pounds per square inch, which is the pressure exerted by the well fluid in that particular well at the pump entrance for the normal casing pressure and normal rate of production, assuming that the rate of production was normal during these tests.

The actual pressure in the column of fluid at the pump inlet may, however, be calculated from the information received by the two fluid level tests described above. That is, by subtracting the original fluid level from the new fluid level, the total difference in level will be found, in this instance 866 feet. Then by subtracting the original pressure on the fluid surface from the new pressure on the fluid surface, a difference of 160 pounds per square inch is found to have been necessary to cause the fluid column to recede 866 feet. By dividing the difference in fluid pressure by the difference in surface level, the density of the mixture of oil and gas in the well (that is, the pressure exerted by this mixture per unit of height of the column of the mixture) may be found. In this instance, the column receded a distance between 3100 feet and 3966 feet, or a total distance of 866 feet, while the pressure difference is 160 pounds. The density of the fluid in the column is such therefore as to exert 0.185 pound per square inch per foot of height of the column.

Hence, knowing the pressure on the fluid surface at any level thereof and knowing the distance below this surface at which the pump inlet is located, a direct calculation of the fluid pressure at the pump inlet may be obtained by the following formulae:

The pressure at any point below the normal surface level in a well at which the level can be maintained by means of gas pressure in the casing is

$$PL1=Pc1+Pg1 \text{ and } PL2=Pc2+Pg2$$

The density of the fluid for the rate of production during the tests is

$$D=\frac{PL2-PL1}{L2-L1}=\text{density of the fluid in lbs. per sq. in. per foot of fluid.}$$

The pressure at the pump is

$$Pa=D(La-L2)+PL2$$

Where

Pc1=gage casing pressure to maintain fluid at level L1.
Pc2=gage casing pressure to maintain fluid at level L2.
Pg1=pressure exerted upon fluid surface by weight of gas above it at level L1.
Pg2=ditto for level L2.
PL1=pressure on the fluid surface at level L1.
PL2=pressure on the fluid surface at level L2.
L1=fluid level corresponding to Pc1.
L2=fluid level corresponding to Pc2.
La=pump location in feet from ground surface.
Pa=pressure at the pump.

In the example shown in Fig. 3, assuming the inlet to the pump is located at the 4700 foot level, the pressure of the fluid at this point would be equal to the sum of the gas pressure at the

casing head for level L2, the pressure exerted by the column of gas above the fluid surface corresponding to this level and the pressure exerted by the column of fluid above the pump inlet. In this instance, the pressure at the casing head is assumed to be 170 pounds per square inch, the effect of the column of gas at this pressure with the fluid level at 3966 feet from the surface being 30 pounds per square inch and the effect of the column of fluid above the pump inlet being 734 feet at 185 pounds per square inch per foot, or 135.5 pounds per square inch exerted by the column of fluid, the result being 335.5 pounds per square inch pressure at the pump entrance. This result is clearly illustrated in Fig. 3 by the point A, the point A being located at 335.5 mark on the abscissae of the chart.

If desired, an estimation of the bottom hole pressure may also be made by continuing the line C downwardly on the chart to intersect the ordinate representing the bottom of the well, such point being indicated at B, or the pressure at any other level in the well below the surface of the well fluid for the rate of production at which the tests were made may be located along the line C. I have discovered that in wells employing mechanical pumps for any given production rate by the pump, the density of the oil-and-gas mixture is constant throughout the height of the standing column of fluid in the annular space between the tubing and casing so that the line C once established continues as a straight line, the effect in pressure per unit of height of the column being constant throughout the height of the column.

Knowing the density of the well fluid and the pressure exerted at the pump inlet, the operator of any particular well may determine whether or not it is practicable to increase the amount of liquid being produced. If the volumetric efficiency of the pump is low and the tests indicate considerable pressure at the pump, he may raise the pump to a level indicated upon the line C at which better separation of gas will usually occur prior to entry of liquid into the pump.

The utilization of the information obtained by the foregoing method will also accurately produce the information of the maximum potential production of the well as by comparing the pressure of the fluid at the pump under two or more different operating conditions of the pump. For example, the static fluid pressure at the pump when the pump is not operating may be measured and compared with the fluid pressure at the pump when the pump is operating at its normal rate of production or at any other rate of production, a comparison of the two values so obtained will produce a constant, indicating the ratio between the rates of production and pressure at the pump inlet, so that by employing this constant at a theoretical zero pump inlet pressure (which would represent the fluid being removed from the well at the rate it flows into the well from the formation) the maximum potential capacity of the well may be found.

Employing the method of determining fluid pressure at the pump hereinbefore described, the static pressure may be readily obtained without necessitating the use of pressure recorders or other devices requiring the removal of or alteration of any of the pumping mechanism and the measurement may be made in wells which have been shut down as readily as in wells which are actively producing.

To obtain the fluid pressure at any point at or below the fluid surface when the pump is not producing fluid, the casing should be closed in and the gas escaping from the well fluid should be allowed to build up pressure in the casing until a stable condition is reached, that is, a point is reached at which no more gas is made by the well (no more gas escapes from the well fluid). When this point is reached, the remaining well fluid in the well may be considered as dense liquid.

Now, by determining the height of the fluid surface under these conditions by my method, the pressure on the fluid surface may be readily determined and by adding thereto the effect of the weight of the column of fluid above any given level, the fluid pressure at that level may be found. This information alone is extremely useful to the operators of producing wells.

The information thus obtained may be plotted on a graph or chart such as that shown in Fig. 4, wherein the ordinates represent fluid pressure at the pump inlet in pounds per square inch and the abscissae represent rate of production of oil from the particular well under consideration, and the static pressure may be plotted at zero production, as indicated by the point D in Fig. 4.

The casing pressure may now be reduced and the pump started and allowed to assume a predetermined rate of production, preferably its normal rate. Assuming this rate is 200 barrels of oil per day, a new determination of the fluid pressure at the pump is made at this rate of production. That is, the pump is started and allowed to operate until the fluid level in the well reaches a stable condition. The location of the fluid level and the pressure in pounds per square inch at the pump inlet under these conditions are determined by the method hereinbefore described and the fluid pressure at the pump is plotted against the production rate on the chart shown in Fig. 4. Assuming that this new pressure at 200 barrels per day is found to be at the point indicated in Fig. 4 at E, a straight line drawn between the points D and E will intersect the zero pressure ordinate at a point representing the maximum potential capacity of the well. In the diagram shown in Fig. 4, this maximum potential production capacity is found to be 300 barrels per day. In other words, if a pump of sufficient capacity is installed in this well and operated in such manner as to remove 300 barrels per day, the oil will be removed at the same rate at which it flows into the well from the formation.

A more accurate determination of the maximum potential production capacity of the well may be made by comparing the fluid pressure at the pump under two different actual producing conditions of the pump, such as by measuring the fluid pressure at the pump when the pump is operating at one production rate, for example, its normal rate, and then changing the rate of production of the pump as by slowing the pump down or changing the stroke of the pump and plotting the relation between the new production rate and the fluid pressure measured by my method, as set forth herein, it will be found that a line intersecting these two points will also represent the relation between production rate and fluid pressure at the pump at any rate of the production by the pump.

As shown in Fig. 5, the normal production rate of 200 barrels per day plotted against the fluid pressure at the pump in pounds per square inch

may be represented upon the chart by the point G while at a reduced rate of production at the pump, say to 100 barrels per day, it will be found that the fluid pressure at the pump is increased so that by determining the fluid pressure under these conditions, the relation between the reduced production rate and the fluid pressure at the pump may be plotted by the point H. A straight line interconnecting the points H and G will intersect the zero pressure ordinate at a point therealong, indicating a maximum possible production of 300 barrels per day. In making such determinations, however, it is desirable that the rate of production of the pump be reduced to at least two-thirds of its normal production rate and preferably to 50% of its normal production rate in order to obtain substantially widely separated points H and G.

Again, it will be noted that all of the necessary calculations to determine the maximum production possible of the well may be made without interrupting the normal production conditions at the well and without requiring the laborious efforts of removing and replacing any of the pump mechanisms.

It will therefore be observed that I have provided a ready method for determining the density of the fluid in any particular well and also for the determination of the fluid pressure at the pump without requiring the removal or alteration of any of the usual mechanism found in the well. It will also be noted that I have provided a ready method for graphically determining the fluid pressure at the pump by first determining the amount of recession of the fluid level due to changes in gas pressure exerted upon the fluid surface and plotting this information upon a graph or chart and extending a straight line intersecting the two or more points so located to a point on the chart representing the level of the pump inlet.

It will also be noted that I have devised a ready means for utilizing the information obtained with respect to fluid levels and gas pressures at the casing head for mathematically determining the fluid pressure at the pump and also for utilizing this information to determine accurately the potential production of any well measured. It should also be noted that all of the measurements necessary to provide for the computations and calculations explained herein may be accomplished without interrupting the operation of the pump except for the measurement of the static pressure as described herein.

While I have shown and described the preferred embodiment of my invention, I do not desire to be limited to any of the details illustrated or described herein, except as defined in the appended claims.

I claim:

1. The method of determining the density of the standing column of fluid in a well, which comprises measuring the stable level of the fluid column under one condition of gas pressure, changing the pressure of gas within the well to move the surface of the fluid column to a new stable level, measuring the new stable level and dividing the change in pressure on the fluid surface required to achieve the new level by the difference in height between the two levels.

2. The method of determining the density of fluid in a well having a casing and a pump suspended therein on tubing and without requiring removal of pump parts, which consists in determining the fluid level in the annular space between the pump tubing and the casing under one condition of pressure, changing the pressure of the gas within the well to move the fluid surface to a new stable level, measuring the new level and dividing the change in pressure on the fluid surface required to achieve the new level by the difference between the two levels.

3. The method of determining the density of the standing column of fluid in a well having a casing and a pump suspended therein, which consists in measuring the level of the standing column of fluid in the well while the pump therein is operated at a given rate of production and under a known condition of gas pressure on the surface of the fluid column, changing the gas pressure on the fluid column, continuing the operation of the pump at the same production rate until the level of the standing column becomes stable at a new location, measuring the new level and comparing the difference in the pressures exerted on the fluid surface at the two levels within the difference in height of the two levels.

4. The method of determining the density of the standing column of fluid in a well having a casing and a pump suspended therein, which consists in measuring the stable level of the surface of the standing column of fluid under one condition of pressure of gas released by the well, measuring the pressure on said fluid surface under said one condition of gas pressure, regulating the flow of gas from the well to increase the pressure of said gas to a different value to depress the surface of said standing column to a new stable level, measuring the new level, measuring the pressure on the fluid surface at the new level, and comparing the difference in the pressures exerted upon the fluid surface under the two conditions of gas pressure with the difference in height of the levels of the fluid surface under the two pressure conditions.

5. The method of determining the density of the standing column of fluid in an oil well having a casing and a mechanical pump suspended therein upon pump tubing and without requiring the removal of pump parts, which consists in the steps of operating the pump under one stable condition of gas pressure in the casing until the fluid level becomes stable, measuring the distance between the casing head and the surface of the fluid under this stable condition, altering the casing pressure to a new condition, operating the pump at the same rate of production under the new condition of gas pressure to again stabilize the fluid level, measuring the distance between the casing head and the new level of the fluid surface under said new stable condition, and measuring the casing head pressures under the two stable conditions, whereby the pressure exerted by the fluid per unit of height of the fluid is represented by comparing the difference in height of the fluid surface levels and the difference between the pressures on the fluid surface required to maintain the fluid surface at the two levels.

6. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted in the standing column of fluid in the well at any desired level below the normal surface of said column and without requiring the removal of any of the pump parts, which comprises measuring the actual stable level of the fluid column under one known condition of gas pressure in the casing, determining the pressure on the fluid surface at that level,

changing the pressure of gas in the well to move the surface of said column to a new actual stable level, measuring the new level of the fluid surface, determining the pressure on the fluid surface at the new level, determining the density of the fluid by dividing the change in pressure on the fluid surface required to achieve the new level by the difference in height of the two levels, and computing the unknown pressure at the desired level by adding to the pressure on the fluid surface at either of the levels the effect in pressure of the column of fluid of the density so determined between the selected actual level and the desired level.

7. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted in the standing column of fluid at any desired level below the normal surface of said column while the pump is operating to remove fluid from the well, which comprises measuring the actual stable level of the fluid under one known condition of gas pressure in the well by sonic sounding method, determining the pressure on the fluid surface at that level, changing the pressure of the gas in the well to move the surface of the column to a new actual level, continuing to operate the pump at the same production rate as for the first condition of gas pressure in the well until the fluid level again becomes stable, measuring the new stable level and determining the pressure upon the fluid surface at this new level, determining the pressure exerted per unit of height of the fluid column by dividing the change in gas pressure on the fluid surface required to effect the change in the fluid level by the difference in height of the two levels, and computing the unknown pressure at the desired level by adding to the gas pressure upon the fluid surface at either of the actual levels the effect in pressure of the fluid column between the selected actual level and the desired level.

8. The method of determining the potential production capacity of a well having a casing and a pump suspended therein, which comprises measuring the stable level of the surface of the standing column of fluid in the well at one known rate of production and under one known condition of gas pressure in the well, determining the pressure on the surface of the fluid column at that level, changing the gas pressure in the well to move the surface of the fluid column to a new stable level, measuring the level of the fluid surface under the new gas pressure condition and determining the pressure on the fluid surface at the new level, dividing the change in pressure on the fluid surface by the difference in height between the two levels to thereby determine the density of the fluid in the column at that rate of production, determining the pressure at some predetermined desired point below the normal fluid surface for that rate of production by adding to the pressure on the fluid surface for either of the measured levels the effect in pressure of the column of fluid between that level and the predetermined desired point, then changing the rate of production by the pump and repeating the fluid level change and gas pressure determinations to determine the density of the fluid in the column and the pressure of the fluid at the said predetermined desired point for the new rate of production and then dividing the difference in the two production rates by the difference in the corresponding fluid pressures at the desired point and using the ratio thus found to determine the maximum rate at which the well is capable of being produced.

9. The method of ascertaining the pressure exerted by the well fluid at any point below the normal surface thereof, which comprises: determining the location of the fluid surface under one condition of pressure of gas on the surface, determining said gas pressure under said one condition, changing the gas pressure to move the fluid surface to a new stable level, determining the new gas pressure on the fluid surface, determining the location of the new surface level and comparing the difference in said gas pressures with the corresponding change in height of the surface level to determine the relation between them, whereby the gas pressure on the fluid surface which is required to maintain the fluid surface at any selected point may be ascertained and which pressure represents the normal pressure exerted in the fluid at said point.

10. The method of ascertaining the pressure exerted by the well fluid at any point below the surface thereof while a mechanical pump is operating in that well, which comprises: determining the stable location of the fluid surface under one condition of gas pressure in the casing of the well; determining the gas pressure on the fluid surface at that level; changing the pressure of gas in the casing to move the fluid surface to a new stable level; determining the new location of the fluid surface; determining the gas pressure on the surface at the new level; and comparing the difference between the pressures on the surface with the corresponding change in the height of the fluid surface to thereby determine the relation between changes in pressure on the fluid surface and the corresponding changes in the location of said fluid surface from which relation the pressure at any selected point may be ascertained.

11. The method of determining the potential production capacity of a well having a casing and a pump suspended therein, which comprises: determining the pressure exerted by the well fluid at some selected point below the normal surface thereof under one known rate of production, by determining the location of the fluid surface under one condition of gas pressure on the surface, determining the gas pressure on the fluid surface under said one condition, changing the gas pressure to move the fluid surface to a new stable level under the same production rate, determining the new gas pressure on the fluid surface, determining the location of the new surface level, comparing the difference in said gas pressures with the corresponding change in height of the surface level, to thereby ascertain the pressure exerted at said selected point under said one rate of production; changing the rate of production from said well; repeating the steps of determining the location of the fluid surface at two stable levels and the gas pressures on said surface to maintain said levels under the new production rate to ascertain the pressure exerted at the same selected point; and comparing the difference in the production rates with the corresponding difference in pressures at said selected point to determine their relation from which the maximum rate of production from the well may be determined.

CRANFORD P. WALKER.

PLAINTIFFS' EXHIBIT No. 3

Patent No. 2,209,944 July 30, 1940

To

C. P. Walker

For

"Method of Measuring Location of Obstructions in Deep Wells."

[Endorsed]: Filed Oct. 6, 1942.

July 30, 1940. C. P. WALKER 2,209,944

METHOD OF MEASURING LOCATION OF OBSTRUCTIONS IN DEEP WELLS

Original Filed Sept. 7, 1937

FIG. 1.

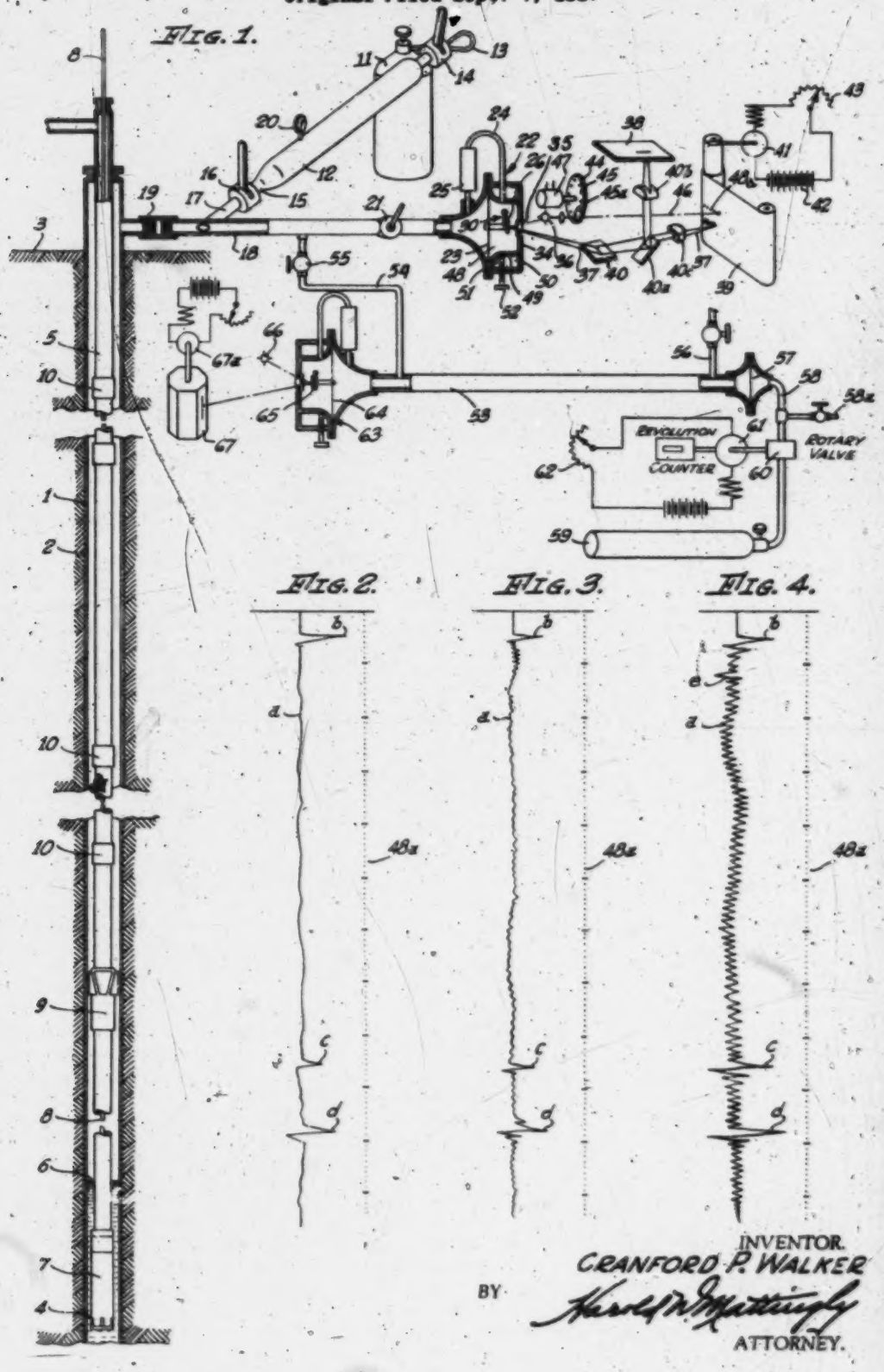


FIG. 2.

FIG. 3.

FIG. 4.

INVENTOR.
CRANFORD P. WALKER

BY

ATTORNEY.

ted July 30, 1940 2,209,944

UNITED STATES PATENT OFFICE

2,209,944

METHOD OF MEASURING LOCATION OF OBSTRUCTIONS IN DEEP WELLS

Cranford P. Walker, San Marino, Calif.

Division of application September 7, 1937, Serial No. 162,699, now Patent No. 2,156,519, dated May 2, 1939. Continuation of application April 29, 1939, Serial No. 270,865. Divided and this application September 25, 1939, Serial No. 296,781

9 Claims. (Cl. 181—0.5)

invention relates to a method of measur- e location of obstructions in deep wells s oil wells and has particular reference hods for determining the location below ound surface of the liquid level in the well, location of tools, pipe sections, couplings r devices which constrict the well bore.

is a division of my copending application No. 162,699, filed September 7, 1937, which ued as United States Letters Patent No. 19 on May 2, 1939, and a continuation of plication Serial No. 270,865, filed April 29, wherein is described and claimed apparatus easuring the location of obstructions and for producing pressure wave echoes in the echoes from certain of the obstruc- are accented so as to make them more distinguishable.

ng the active life of an oil well it is de- from time to time to determine the loca- the fluid level within the well for the pur- determining the type of pumping appa- nost desirable to be used, determining the flow of oil into the well, and for making determinations desirable in the most effi- peration of the well.

methods of determining the location of the evel or the location of other obstructions well have been generally of two types, one ch measuring apparatus has been lowered he ground surface to determine by the of cable or the line extended into the well pth or location of the fluid or other ob- ons encountered by the instrument as it red. Among devices to be lowered into the also included a pressure recorder which lowered into the well on a wire, the length ich is metered to determine the static e in the well at different levels, a varia- which includes a pressure recorder with driven chart lowered on the bottom of mp to obtain a record of the operating es or levels of the fluid. A further varia- that of lowering a bailer upon a rope and measuring the wetted surface of the rope eatedly lowering the bailer until it brings d, measuring the length of the line upon ccurrence. The other method is that of ing sound waves in the well and noting psed time between the introduction of the and its return as an echo from the sur- the liquid or other obstruction encoun-

her of these methods is satisfactory, the aving the disadvantage of requiring the removal of oil flow tubing, sucker rods and other apparatus normally disposed in the well prior to the time the instrument is inserted in and lowered into the well, requiring a considerable length of time both for the removal of such apparatus, the reinsertion of the apparatus, and the making of the actual measurement. The other method is unsatisfactory primarily because of the relatively low intensity or energy which can be employed in the sound wave so that the echo received back is of such low energy as to prevent its accurate detection and, further, little or no distinction is made by reason of such low energy between various types of obstructions encountered by sound waves.

A third method, namely, that of introducing a shock of relatively high intensity into the well, creating thereby a pressure wave which travels through the well, and measuring the elapsed time between the introduction thereof and the echo thereof, to give an indication of the depth of the fluid level and other obstructions, has been introduced, one form being that of creating a relatively loud noise such as a shot or an explosion in the well, another form being illustrated and described in United States Letters Patent No. 2,047,974, issued to Harold J. Wyatt and Paul E. Lehr on July 21, 1936. This latter method has the desirable characteristic of permitting the employment of relatively high intensity in the wave or impulse produced in the well and it is an object of my invention to improve upon the method disclosed in that patent and to eliminate or materially reduce factors of error encountered in the employment of that method.

Another object of my invention is to provide a method of measuring the location of fluid level or other obstructions in well bores, in which the intensity of the pressure impulse introduced into the well may be varied to compensate for well depth and the character of the gaseous media through which the wave must travel to produce an echo of sufficient intensity to permit the same to be readily detected and translated.

Another object of my invention is to provide a method as set forth in the preceding paragraph wherein the pressure impulse may be so varied as to allow the detection and the separate determination of the location of a plurality of obstructions which may be encountered in the well.

Another object of my invention is to provide a method for the measurement of the location of fluid level or other obstructions in a well bore in which the pressure impulse introduced into the well produces an indication both of the fluid level

612

and of the location of other obstructions in the well bore.

Another object of my invention is to provide a method of the character set forth in the preceding paragraph wherein the same pressure impulse introduced into the well to measure the fluid level or the location of other obstructions is employed to determine the velocity of the wave in the particular media encountered in the well.

Another object of my invention is to provide a method as set forth in the preceding paragraph wherein, knowing the location of one or more obstructions, tools or other devices in the well bore, the velocity of the wave within the well bore may be accurately determined from echoes produced thereby and enabling an operator to determine the unknown location of the fluid level by the mere measure of the elapsed time between the introduction of the impulse into the well and the reception of a distinguishable echo from the fluid level, without necessitating introduction of corrective factors or other separate measurement of and determination of the character of the media in the well.

Another object of my invention is to provide a method for determining the location of fluid levels in well bores in which the location of and the number of tubing sections in the well may be determined by the same pressure wave created to measure the depth or the location of the fluid level.

Other objects of my invention will be apparent from a study of the following specification, read in connection with the accompanying drawing, wherein

Fig. 1 is a diagrammatic view illustrating a typical well cross section and the location and character of the apparatus required for determining the fluid level or location of other obstructions in the well in accordance with my method;

Fig. 2 is a diagrammatic view illustrating the type of record or indication which may be made with my method in its simplest application;

Fig. 3 is a diagrammatic view similar to Fig. 2 and illustrating the type of record or indication which may be made with my method but in which echoes produced by intermediate obstructions are not amplified; and

Fig. 4 is a diagrammatic view similar to Figs. 2 and 3 and illustrating the type of record or indication which may be made with my method, including the amplification of echoes from intermediate obstructions.

The method disclosed in United States Letters Patent issued to Wyatt and Lehr, hereinbefore referred to, is briefly that of introducing into a well bore a pressure impulse, either positive or negative, which may have any desired frequency as by the introduction into the well of a quantity of gas of known pressure and volume, the introduction of this impulse into the well producing a wave which will travel down the well until it encounters the fluid surface in the well and then the wave will be reflected and will travel back up the well to the ground surface where the echo or return wave may be detected, the measurement of the elapsed time between the production of the impulse and the arrival at the ground surface of the echo constituting a measure of the location of the fluid level by the simple calculation of the elapsed time multiplied by the rate of travel or the velocity of the wave in the well. In making such calculations, it is correctly assumed that the wave will act like an acoustical wave and its velocity will be the same as that of a sound wave. In air at normal temperatures and approximately sea level pressure this rate would be 1100 feet per second but the gaseous content or media in the well is ordinarily not the same as air and correction must be made for the density, temperature or other characteristics of the particular media encountered in the well, it being well known that the higher the temperature or the lower the density of the gaseous media through which the impulse travels the greater the velocity of the wave.

In employing the method as set forth in the said patent, an approximation of the fluid level may be readily determined and this approximation or measurement may be determined in a relatively short length of time, without requiring the removal or disturbance of any of the apparatus contained within the well bore. However to determine the fluid level with considerable accuracy, the rate of travel of the wave in the particular media encountered in any particular well must be known or must be determined since the density, temperature and character of the gaseous media in wells varies in each different oil field and in each individual well. I provide means for readily determining the pressure wave velocity in any particular well, which may be arrived at as follows:

In Fig. 1, I have illustrated a typical oil well comprising the earth bore 1, usually lined with casing 2 or pipe of relatively large diameter, extending from the ground surface at 3 to the oil bearing sands at 4 where the casing is either perforated or is provided with a perforated liner through which the oil from the sands may enter to the interior of the casing. The casing is, of course, constructed of a plurality of lengths of pipe secured together by couplings or collars in any well known manner. A second pipe or string of pipes extend down through the casing 2, the string of pipe being known as the oil flow tubing indicated at 5, extending from the ground surface down to a position disposed below the level of the fluid in the well, which is indicated at 6, the lower end of the tubing string 5 having a pump 7 of any desired character located therein. Such pumps are usually operated by means of a string of sucker rods 8 which extend upwardly through the tubing string 5.

It is the common practice to employ in the tubing string 5 a tubing catcher 9 which may be of any of the well known constructions, the tubing catcher being usually located a relatively short distance above the level of the pump in the well so that should the tubing string break the tubing catcher 9 will grip the casing and prevent complete destruction of the tubing string. One or more of the tubing catchers 9 may be distributed throughout the length of the tubing string.

The tubing string 5 is constructed of a plurality of lengths of pipe coupled together by means of collars 10, which collars are usually of somewhat larger outside diameter than the outside diameter of the tubing from which the oil flow tubing is made.

Hence it will be noted that in the ordinary oil well there are a plurality of obstructions, each of which is capable of receiving and reflecting a sound wave or pressure wave passing down through the well, these obstructions including the fluid surface 6, the tubing catcher 9 and each of the collars 10 of the tubing string.

In most wells the length of the tubing string between the ground surface 3 and the pump

is known, that is, records are usually kept showing the length of each tubing string section and the number of such sections located within any given well. Particularly, records are usually kept as to the location along the tubing string of the catcher 9 so that by referring to these records an absolute calculation or determination of the distance between the ground surface and the tubing catcher or liner top is known. Hence to determine the location of the fluid level 6, it is only necessary to produce in the well a pressure impulse which will create the low frequency wave, and then translate the echoes received from the well in terms of echo impulses received from the tubing catcher or liner top and from the liquid surface. By comparing the time lapse between the production of the pressure impulse and the receipt of the echo from the tubing catcher with the time lapse between the creation of the pressure impulse and the receipt of the echo from the fluid surface, a positive and accurate measurement of the location of the fluid level may be obtained. That is, if the known location of the tubing catcher is 5000 feet below the ground surface and it is desired to know the height of the fluid in the well, all that is necessary is to produce a pressure impulse, note or record the echo from the tubing catcher, and note or record the echo received from the fluid surface.

The time lapse between the creation of the pressure impulse and the receipt of the echo from the tubing catcher denotes the velocity of the pressure wave in the particular media encountered in that particular well so that by measuring the additional elapsed time between the receipt of the echo from the tubing catcher and the receipt of the echo from the fluid surface, an accurate measurement may be obtained and no compensation need be made for possible errors due to different velocities of waves in different media because the mean velocity of the wave from the ground surface to the tubing catcher and return is the same as the mean velocity of the wave from the ground surface to the fluid surface and return.

The only item which must be provided for is that of producing a pressure wave echo of such magnitude and of such character that the echo from the tubing catcher can be distinguished from the echo received from the fluid surface.

As illustrated in Fig. 1, this distinction may be readily made by providing a suitable source of fluid pressure indicated at 11 which may be a tank, compressor or other source of fluid pressure at any desired value. It follows, of course, that the pressure impulse which must be produced in the well must be at a greater pressure than the pressure of gases in the well so that the pressure source 11 must be capable of delivering a pressure impulse having a considerable differential over the static pressure of gases in the well or flowing therefrom. For example, if the well gases at the surface of the well are at a pressure of 500 pounds per square inch, the source of fluid pressure 11 must be capable of delivering, say, 600 pounds per square inch or more in order to create a pressure impulse of, for example, 100 pounds pressure differential.

The pressure source 11 is illustrated as being coupled to a pressure chamber 12, one end of which is connected as by means of tube 13 and valve 14 to the pressure source 11, while the opposite end of the pressure chamber 12 is connected by means of a nipple 15, a quick opening valve 16 and a nipple 17 to a length of pipe 18 which is in turn coupled as indicated at 19 to the well casing 2. The pressure chamber 12 is preferably provided with a suitable indicating pressure gage 20 by which the pressure within the pressure chamber 12 may be readily measured. Thus for the production of the pressure wave all that is necessary is to close valve 16, open valve 14 and allow pressure to be built up in the pressure chamber 12 to the desired pressure value, say, 600 pounds per square inch. Then the valve 14 is closed and valve 16 opened, allowing an impulse of 600 pounds per square inch to be injected into the well casing (the static pressure in which is, for example, 500 pounds per square inch).

A receiving device for receiving and registering the echoes of the pressure impulse from the various obstructions within the well is illustrated as including the pipe 18 and pressure responsive device coupled thereto through a valve 21 to a diaphragm chamber 22, permitting a flexible diaphragm 23 to be placed into communication with the casing 2 whenever the valve 21 is opened. To control the sensitivity of response of the diaphragm 23 and in order to prevent undue distortion of the diaphragm 23 by the static pressure in the well and to avoid damage which would result therefrom, I prefer to allow the static pressure in the well casing 2 and pipe 18 to be equalised on both sides of the diaphragm 23 as by providing a by-pass 24 providing a restricted passage through which gas pressure in the chamber 22 on one side of the diaphragm may pass to the opposite side of the diaphragm, the filter 25 being interposed in the by-pass if desired to dry out the gas and prevent undue corrosion of the more delicate parts of the device contained in the diaphragm chamber 22. Attached to the diaphragm 23 is a mirror 26. In the front wall 34 of the diaphragm chamber 22 I mount a lens 35, through which light from a suitable light source 36 may pass into the chamber 22 to be reflected by the mirror 26, the reflected beam 37 passing back through the lens 35, as a ribbon beam which may be reflected or directed upon a ground glass screen 38 and upon a recording chart or strip of sensitized tape 39 to make a permanent record of the path described by the light beam 37. Suitable reflectors, such as indicated at 40, may be employed to direct the beam in any desired direction while a reflector 40a may be interposed in a portion of the ribbon beam 37 to direct a portion thereof upon the screen 38, suitable condenser lenses 40b and 40c being interposed in the beam to draw the same to a point beam upon the screen 38 and tape 39.

Thus as the pressure within the casing 2 is varied as by the pressure wave resulting from the pressure impulse created within the casing 2, the mirror 26 will be moved, the amplitude of its movement representing the amplitude of the pressure variation. As the echo of the pressure impulse from any obstruction within the well is received upon the diaphragm 23, the mirror 26 will be moved in accordance with the amplitude of the echo impulse and will cause the echo impulses to be registered for observation, both by directing the light beam 37 upon the ground glass 38 where the amplitude of the echo may be visually observed and by directing the light beam 37 upon the recording tape 39, a permanent record of the pressure wave which is created within the casing 2 may be made and this wave or chart will show peaks of varying amplitude, each of which peaks represents an echo from a particu-

lar obstruction within the well, either the tubing collars 10, the tubing catcher 9 or the fluid surface 6.

The sensitized strip 39 may be arranged to be driven at any desired speed by means of a variable speed motor 41 coupled to a suitable source of current 42 through a rheostat or other speed adjusting device 43 so that the tape or strip 39 may be driven at variable speeds.

By employing some device which will produce upon the record strip 39 a time lapse measurement, a direct comparison between the path described by the light beam and the lapse of time may be accomplished. I prefer to provide such mechanism including means for producing upon the strip 39 a series of dots or marks, each of which represents a fraction of a second, the line of dots or marks extending substantially parallel to the general direction of the wave chart described by the light beam 37. This may be readily accomplished by providing a disc 44 having a plurality of openings 45 therein adapted to be rotated in the path of a secondary light beam 46 emanating from the light source 36. The light beam 46 passing through the openings of the disc 44 may be projected upon the same sensitized strip 39 to describe a series of marks thereon, one for each of the openings 45.

One of the openings 45a is preferably larger than the remainder so that upon each revolution of the disc 44 a distinguishing mark will be produced. Thus by providing ten openings 45, a series of marks 48a may be produced upon the record strip 39 representing ten equal divisions. The tenth mark being produced by the large opening 45a is of greater length or of greater size or in some other manner distinct from the remaining nine marks. By providing the disc 44 with any suitable time mechanism such as a synchronous motor 47, the marks produced upon the charts will represent lapse of time; for example, each mark representing $\frac{1}{10}$ of a second while the space between the distinct marks will represent lapses of one second each.

Due to the fact that the depth of wells varies considerably and, further, due to the fact that conditions of obstruction or constriction of the space between the well casing 2 and the tubing string 5 varies considerably in different wells, the same pressure differential cannot be used successfully in all wells and it is necessary to vary the pressure impulse through considerably wide limits, dependent upon the conditions encountered at a particular well. For this reason I prefer to direct a portion of the beam 37 upon the ground glass screen 38 so that by firing one charge of gas pressure into the well and observing the path described by the light beam, a determination of whether or not the correct pressure impulse is being used may be made. For example, one pressure impulse which is estimated to be correct for a given well may not produce a sufficient fluctuation in the echo waves received from the tubing catcher and the fluid surface, and a higher pressure or greater quantity of gas must be used in order to create the desired impulse. Thus by observing the effect of a succession of pressure impulses liberated into the well, the person making the survey will be able to determine which of the echoes rebounds from the tubing catcher and which of the echoes rebounds from the fluid surface and thus determine when distinguishable echoes are being received from the different obstructions in the well.

The typical desired configuration of the path described by the light beam 37 is indicated in Fig. 2 wherein *a* represents the path described by the light beam as a result of the pressure wave created by a discharge of gas from the chamber 12 into the well casing. From an inspection of the line *a*, it will be noted that this line is a relatively straight but somewhat wavy line, having distinct peaks at *b*, *c* and *d*. The peak *b* is that which will be produced by the deflection of the diaphragm 23 when the impulse of gas from the chamber 12 is liberated into the casing 2. At a predetermined time thereafter, dependent upon the velocity of the wave in the particular well, a peak *c* will be produced as a reflection from the tubing catcher 9, while at a predetermined time thereafter an additional peak or series of peaks will be produced at *d* as a reflection of the wave from the fluid surface.

Thus by observing the effects of a series of pressure impulses of different intensity or pressure, the operator may determine which impulse is most desirable to produce the distinctly recognizable and differentiatable peaks *c* and *d*, allowing him to differentiate between echo from the tubing catcher (or such other obstructions as may be known to be in the well) and the echo from the fluid surface. As hereinbefore stated, knowing the depth or location of the tubing catcher 9, the comparison of the elapsed time between the peaks *b* and *c* and the elapsed time between the peaks *b* and *d*, an accurate determination of the fluid level may be produced.

After the most desirable magnitude of pressure impulse has been determined, the motor 41 may be set into action and a permanent record of the path described by the light beam may be made upon the sensitized film 39 with assurance that the various peaks *b*, *c* and *d* will be readily distinguishable upon the diagram so produced.

As will be observed from an inspection of Fig. 2, the diagram on the strip 39 also shows the plurality of spaced dots or other means of indicating elapsed time, such series of dots being indicated at 48a.

Having made a diagram as indicated in Fig. 2, a direct measure and determination of the fluid depth may be achieved. Also it will be observed that by selecting impulses of the desired magnitude, reflections from other obstructions in the well may be noted and recorded, thus assisting in the location and determination of other restrictions as well as a measurement of the fluid level.

For example, each of the collars 10 of the tubing string will produce a distinct echo differentiatable from the echoes from other sources. This allows the accurate measurement of the fluid level in a well where, by reason of failure to keep records or loss of records, the location of the tubing catcher is not known or wherein the catcher is submerged or is omitted. For example, in some wells tubing has been drawn out and replaced by other tubing and no record has been made of the lengths of tubing drawn out or the lengths of each section drawn out or the length or number of tubing sections employed to replace them so that to merely compare the time distance between the peaks *b* and *c* would not give a true indication of the velocity of the wave in the particular well. However, if it is reasonably assured that each of the tubing lengths is approximately the same, and the usual practice in oil wells is to employ tubing lengths in a given well, all of which are approximately the same, an indication of the number of tubing lengths located within any

given well, multiplied by the average length of a tubing section, will give a true measure of the location of the tubing catcher or the location of the pump or other device which constitutes an obstruction in the well. For example, by selecting a desired pressure impulse, by comparison of a succession of pressure impulses and the waves produced thereby, upon the ground glass 38, a wave or line of the character indicated at *a* in Fig. 3 may be produced wherein, though it is still wavy, it is produced by a series of peaks *e*. By counting the number of these peaks, each of which represents a reflection back from a collar 10, the number of lengths of tubing between the peaks *b*, *c* and *d* may be determined.

However, in actual practice it is found that irregularities in the annular space between the tubing and the casing, such as may be caused by imperfect abutment of adjacent casing sections or the presence of tubercules upon either the casing or the tubing will produce undesired echoes and will produce upon the record chart peaks which cannot readily be distinguished from those resulting from the echoes from the tubing collars, and I prefer therefore to provide some means which will be so tuned with the tubing collar echoes as to amplify or accent them and which will tend to dampen or filter out the undesired disturbance vibrations. As will be understood by those familiar with acoustics, if upon the multiplicity of sound waves emanating from the well as a result of the desired echoes and the disturbances there is superimposed another wave so tuned to the desired echo wave as to beat with it, the desired wave will be amplified and accented while the other or disturbance waves will tend to be damped out.

By selecting the correct length for the pipe 18, that is, by selecting the correct distance between the casing 2 and the diaphragm 23, a tuned wave may be produced which will affect the movements of the diaphragm 23. Since it is desired to count the number of tubing collars, all that is necessary is to lengthen or shorten the pipe 18 until it is tuned to one of the harmonics of the impulses or echoes produced by the collars 10. From experience it has been found that selection of the pipe 18 of approximately one-third of the length of a section or joint of the tubing 5 a third harmonic is produced which beats with the impulses echoed from the tube collars 10 to produce magnified or amplified peaks *e* and permits the ready distinguishing of the impulses produced by the collars 10 from other impulses.

I prefer, however, to employ in the length of the pipe 18 an adjustable coupling 19 which allows the accurate lengthening or shortening of the pipe 18 until, by observing the path of the light beam upon the ground glass 38, a distinct pattern is made represented by the line *a* on Fig. 4, in which each of the intermediate peaks *e* is amplified as indicated in Fig. 4 so that it is readily recognizable.

The adjustment of the coupling 19 should be made until, with a given pressure impulse, a uniform deflection of the mirror 36, that is, a uniform amplitude of the peaks *e*, is achieved, and by observing this upon the ground glass 38 the operator will note when the pipe 18 is of such length as to be "tuned" with the tubing lengths.

Thus, even though the location of the tubing catcher is not known, if the average length of tubing section is known, the production upon the strip 39 of a diagram such as shown in Fig. 4 allows the counting of each of the collars 10 and a clear understandable record is made of the length of tubing string between the impulses *b*, *c* and *d*, permitting the quick and accurate location and determination of the exact level of the fluid in the well.

As is described and claimed in my copending application Serial No. 270,866, filed April 29, 1939, an elongated tube or pipe 53 coupled as by means of a short pipe 54 to the pipe 18 and controlled by a valve 55 in such manner as to permit gas from the casing 2 to flow through the pipe or tube 53, thus providing in the pipe 53 an atmosphere corresponding to the atmosphere or gaseous medium in the casing 2. An open exhaust pipe 56 leads from the opposite end of pipe 53 open to the atmosphere or connected to a gas flow line so that the pressure within the pipe or tube 53 will remain substantially constant as of the value of the gas in the casing 2. Near one end of the tube 53, a diaphragm 57 may be provided and arranged to be vibrated at any desired frequency as by coupling the diaphragm 57 by a pipe 58 open to the atmosphere at 58*a*, to a source of fluid pressure, such as compressed air, indicated at 59. A rotary valve 60 is interposed in the pipe 58 and arranged to be driven by means of a variable speed motor 61 regulated as to speed by means of a suitable rheostat or other controlling device 62 so that by rotating the motor 61 at any speed a series of pressure impulses will be created in the pipe 58, and will beat upon diaphragm 57 to create a pressure wave in the tube or pipe 53 of known frequency, the frequency being variable by varying the speed of motor 61.

At the opposite end of the pipe 53 I couple a pressure responsive device which may be constructed in the same manner as the diaphragm chamber 22 and diaphragm 23 hereinbefore described. This pressure responsive device is illustrated at 63 coupled directly to the end of the pipe 53, the diaphragm 64 of which receives the impulses transmitted through the pipe 53 to vibrate in response thereto and to move a mirror 65 in the same manner as was described with reference to the mirror 26. The mirror 65 reflects a light beam from a suitable source 66 upon a polygon of mirrors 67 revolved by means of an adjustable speed motor 67*a* at a speed synchronous with the speed of the motor 61 so that the amplitude and uniformity of the vibrations of the diaphragm 64 may be visibly observed.

As is well known in the art, each gaseous medium, variable as to density, temperature, etc., is resonant to pressure waves or sound waves of predetermined frequency. Thus by varying the speed of operation of the motor 61 until the pressure impulse created by the diaphragm 57 makes one round trip (or multiple thereof) to the diaphragm 64 and back to the diaphragm 57 in time to just synchronize with the next impulse created by the diaphragm 57, the pattern described by the beam of light on the mirrors 67 will show maximum amplitude, and noting the frequency of the impulses produced upon the diaphragm 57 (that is, noting the speed of the motor 61) the velocity of the sound through this particular gaseous medium may be readily determined by comparing this frequency with the frequency at which a condition of perfect resonance is achieved in the pipe 53 with air in it.

It will therefore be observed that I have provided a method of determining the location of obstructions in wells and accurately locating and measuring the fluid level in a well without the

necessity of removing any of the apparatus from the well, the entire measurement and determination being accomplished in a relatively short time.

It will be understood by those skilled in the art that the creation of pressure impulses within the well may be accomplished by decreasing the pressure in the well instead of admitting a charge of gas from the pr sure chamber 12 into the well. For example, if the pressure in the well is relatively high, the valve 16 in the pressure chamber may be closed and the valve 14 opened, allowing the pressure in the chamber 12 to reduce to some value less than the casing head pressure of the well. Then by closing valve 14, and opening valve 16 a measured quantity of gas will rapidly discharge or surge into the chamber 12, creating a pressure impulse within the well which acts in the same manner as hereinbefore described for the introduction of pressure from the tank or other source 11.

It will also be understood that if desired special constrictions may be placed in the well for future measurements of the fluid level therein to take the place of the tubing catcher 9. Such constrictions could comprise a closed cylinder of pipe surrounding and attached to one of the tubing sections when the tubing is run into the well and by noting and recording the location of such constriction, the future measurements of the fluid level by my pressure impulse method can be readily determined, employing the reflection of the wave from the restricting member in place of the reflection from a tubing catcher 9 or other restriction in the well.

While I have shown and described the preferred embodiment of my invention, I do not desire to be limited to any of the details of construction shown and described herein, except as defined in the appended claims.

I claim:

1. The method of accurately determining the unknown location of an obstruction in a well having a string of tubing therein constructed of a plurality of lengths of tubing, each of approximately the same length and connected to each other by couplings, which consists in creating a pressure impulse in the annular space between the tubing and casing of the well, registering the echoes from the tubing collars and from said obstruction, and counting the tubing collar echoes occurring between the creation of the pressure impulse and the echo from the unknown obstruction, to determine the location of the unknown obstruction.

2. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating an acoustical impulse in the annular space between the tubing and the well casing to produce echoes from portions of the tubing string distinguishable from each other and from the echo from the unknown obstruction, observing the lapse of time between the arrival at a predetermined point of the echoes from successive portions of the tubing string to thereby determine the velocity of the pressure wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

3. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating an acoustical impulse in the annular space between the tubing and the well casing of such magnitude as compared with the depth of the well and the resistance to pressure wave transmission therethrough as will produce echoes from portions of the tubing string distinguishable from each other and from the echo from the unknown obstruction, observing the lapse of time between the arrival at a predetermined point of the echoes from successive portions of the tubing string to thereby determine the velocity of the pressure wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

4. The method of determining the unknown location of an obstruction in a well having a casing with tubing therein restricting the volume of the annular space within the casing and having another obstruction therein at a known location above the unknown obstruction, which consists in creating in the annular space an acoustical impulse to produce echoes from different obstructions distinguishable from each other, observing the time lapse between the creation of the impulse and the arrival at a predetermined point of the echo from the known obstruction, comparing with said time lapse the time lapse between the creation of the impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

5. The method of determining the unknown location of an obstruction in a well having a casing with tubing therein restricting the volume of the annular space within the casing and having another obstruction therein at a known location above the unknown obstruction, which consists in creating in the annular space an acoustical impulse of such magnitude as compared with the depth of the well and the resistance to pressure wave transmission therethrough as will produce echoes from different obstructions distinguishable from each other, observing the lapse of time between the creation of the impulse and the arrival at a predetermined point of the echo from the known obstruction to thereby determine the velocity of the pressure wave in that particular well, and measuring the lapse of time between the creation of the impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

6. The method of determining the unknown location of an obstruction in a well, which consists in placing another obstruction in the well at a known depth in the well, creating a pressure impulse in the well, observing the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo thereof from the obstruction of known location, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

7. The method of determining the unknown location of an obstruction in a well having a casing with tubing therein restricting the volume of the annular space within the casing and having an approximately known depth and a known pressure of gas within said space, from which the approximate magnitude of acoustical impulse required to traverse the restricted space and produce echoes from the several obstructions in the well may be estimated, which consists in introducing into said space between the casing and

tubing a series of acoustical impulses, each of different magnitude approximating the estimated magnitude to produce from each impulse echoes from the different obstructions in the well, observing the echoes that are produced by each impulse to select the one that produces distinguishable echoes from each of the obstructions in the well, and recording the echoes of an impulse of the selected magnitude in the relative times and order in which they are received at the ground surface.

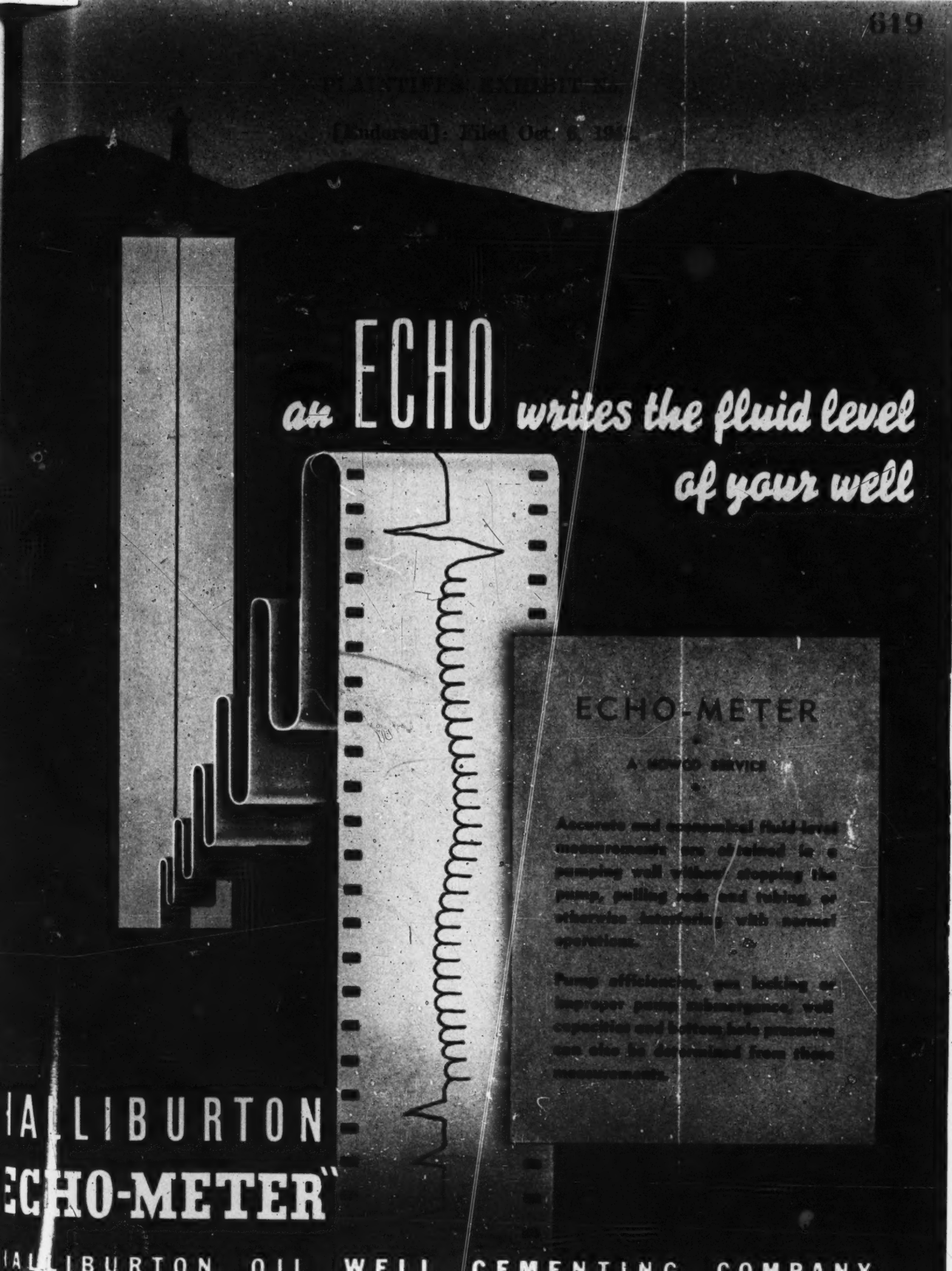
8. The method of determining the unknown location of an obstruction in a well having a string of pipe therein consisting of sections of known mean length connected by couplings, which consists in creating an impulse in the well adapted to produce an echo from each of a plurality of successive couplings and from the obstruction of unknown location, and sequentially registering the impulse and such echoes in spaced relation to each other proportional to the actual relative spacing of the couplings and the unknown obstruction, and computing the distance to the unknown obstruction from said known mean length between successive couplings and the number of registered coupling echoes.

9. The method of determining the distance to an unknown location of an obstruction in a well having a casing with tubing therein restricting the volume of the annular space within the casing and having another obstruction therein at a known location, which consists in creating at some known point within the casing an impulse to produce echoes from said obstructions distinguishable from each other, sequentially registering the impulse and the echoes from said obstructions in spaced relation to each other, and determining the distance to the unknown obstruction from said known point of impulse by comparing the elapsed time between the registrations of the impulse and the echo from the known obstruction with the elapsed time between the registrations of the impulse and the echo from the unknown obstruction.

CRANFORD P. WALKER.

PLAINTIFFS EXHIBIT No.

[Endorsed]: Filed Oct. 6, 194[illegible]


an ECHO writes the fluid level of your well
ECHO-METER
A HOWCO SERVICE
Accurate and economical fluid-level measurements are obtained in a pumping well without stopping the pump, pulling rods and tubing, or otherwise interfering with normal operations.
Pump efficiencies, gas locking or improper pump submergence, well capacities and bottom hole pressures can also be determined from these measurements.
HALLIBURTON
ECHO-METER"
HALLIBURTON OIL WELL CEMENTING COMPANY

Halliburton ECHO-METER

For Accurate Fluid Level Determinations

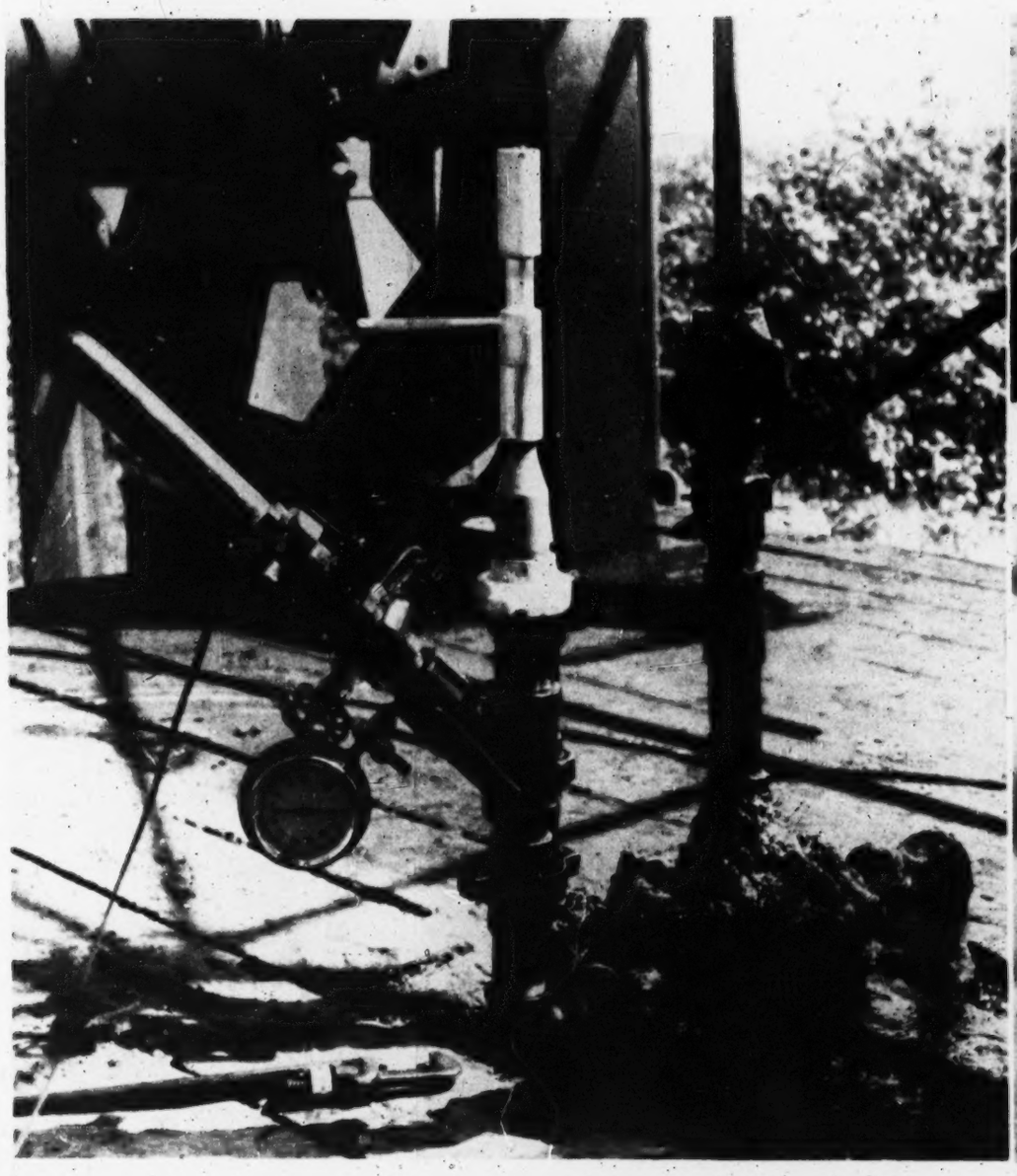
NOTE: The following pages are intended to acquaint the oil industry with the operation and application of a new HOWCO instrument, the ECHO-METER, which is not only an important aid in the production of oil but which is becoming helpful in the solution of many drilling, acidizing and cementing problems.—Daniel F. Elam, Echo-Meter Supervisor.

The ECHO-METER is an electrically operated instrument for recording the travel of a sound wave in an oil well, thereby locating the fluid level and certain other obstructions, and obtaining important bottom-hole information.

All measurements are made at the casing-head of the well, and it is not necessary to lower any kind of a mechanical device into the hole. No pulling of rods, tubing, or alterations of any kind to the well equipment are necessary, nor is expensive auxiliary equipment required. Production of oil or gas does not interfere with the normal use of the instrument, and the well can continue to pump, flow, or gas-lift while the measurements are being taken if it is so desired.

The ECHO-METER is an ideal instrument for measuring the fluid build-up, obtaining subsurface pressures, potentials, or productivity indices on producing wells. Data are quickly obtained for increasing pumping efficiencies. Other uses include measurements in drilling wells where mud circulation has been lost, or as a control instrument in certain acidizing and cementing procedures.

Versatility and speed of the equipment, plus accuracy and simplicity of the method, make the service extremely useful.



The Casinghead Unit can be con
taken from the car, and attached t

ECHO-METER EQUIPMENT

The ECHO-METER is simple. Complete equipment is carried in a 4-passenger coupe, with one jump seat removed to accommodate the instruments. Space for appurtenant apparatus is provided in the rear of the car. The equipment consists principally of an electrical Amplifier, a pen Recorder, and a Casinghead Unit. Only the Casinghead Unit is unloaded from the car at any time. This Unit connects to all standard well heads by a 2" nipple and quick-change union; it can be attached by an ell or other convenient fitting, and used in any position—horizontal, vertical, or otherwise. The Unit comprises a gun, for initiating a sound wave, and a microphone for detecting the echoes of this wave from the well.

The ECHO-METER is practical. The special type microphone used is extremely sensitive to the low frequencies which convey the desired informa tion; yet it is undersurbed by the high frequencie which are due to reverberations in the casing or t mechanical impacts. The results of a hamme blow on the outside of the microphone housing i hardly visible on the record, whereas a gentle wavin of the hand past the microphone gives a strong an unmistakable signal.

The ECHO-METER is rugged. The Amplifier i of special trouble-free design which will amplify lo frequencies without distortion. It incorporates microphone current control, multi-circuit curren meter, dynomotor power supply, and the necessar control relays and switches, in addition to an electr cal filter for eliminating disturbances caused b pumping or gas noises.

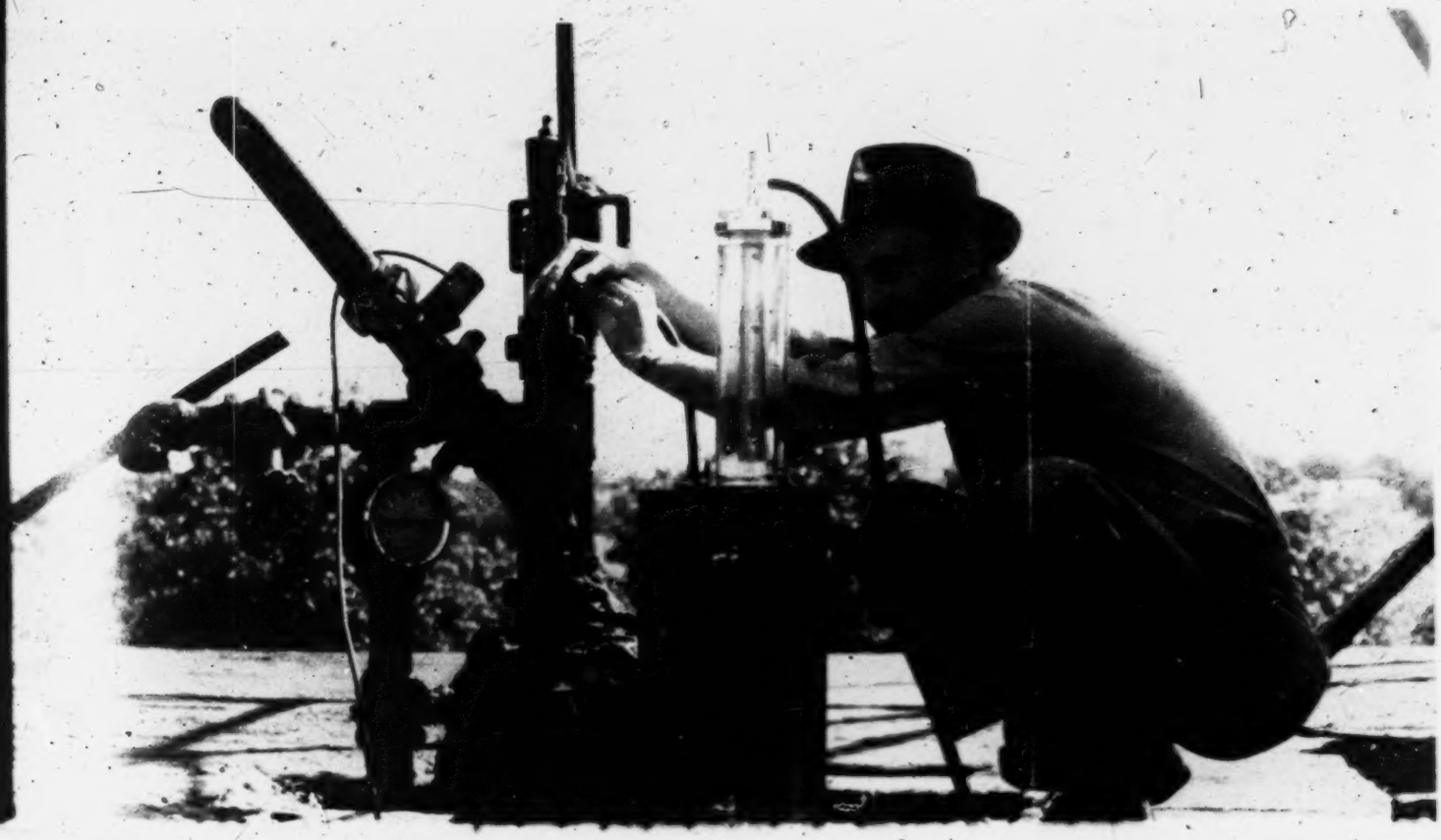
The ECHO-METER is convenient. Among the exclusive features is the electromagnetic Direct-Writing Recorder. It records an ink line directly on a continuous moving 35mm. paper tape, which passes under the recording pen at a known constant speed. The sprocket perforations in the tape serve as timing marks, while the ink trace is a record of well depth. The ink recorder completely eliminates the delay and inconvenience encountered by photographic methods. It also affords the operator visual control of his record at all times, enabling him to continuously and properly increase the electrical amplification of the weaker signals from the deeper parts of the well as they are being recorded.

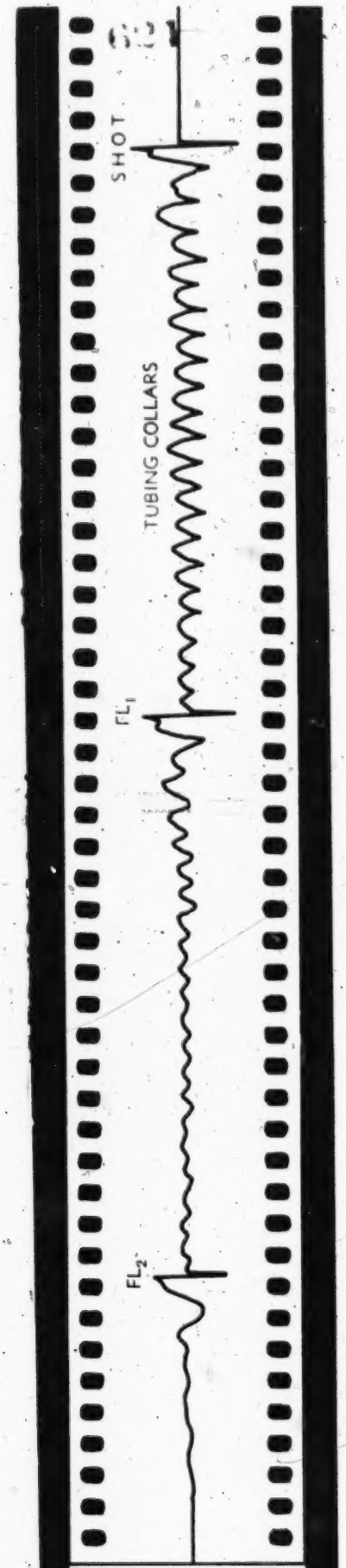
PRINCIPLE OF OPERATION

A steep-front sound wave is created in the Casing-head Unit by automatically firing a blank cartridge through a flame arrestor. When the cartridge is discharged, the sound wave goes down the annular space between the tubing and casing. All obstructions encountered by the wave give rise to reflections in proportion to the size of the obstruction; tubing collars give small reflections and tubing catchers and liner tops give larger reflections, while the fluid surface reflects almost all of the wave reaching it. No reflections are obtained below the fluid surface. The equipment is responsive to either compressional (positive) or rarefaction (negative) waves. Therefore, whenever desirable, tubing collars can be recorded inside the tubing instead of outside, provided the tubing is shut-in and is not full of fluid.

Pen and ink records are quickly computed.

Auxiliary tests can be completed while at the well.





Record 1

Shows multiple reflections caused by reciprocation of the initial sound wave. Normal dissipation of the wave energy can be noted by comparison of the two reflections.

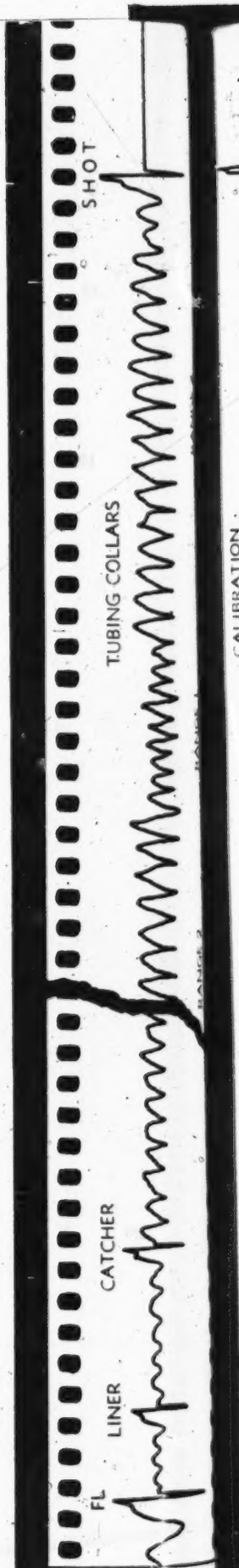
Energy from the shot, and likewise from the reflected sound wave, is picked up by the microphone and transformed into electrical energy. It is then carried by a plug-in cable from the mike in the Casinghead Unit to the instruments mounted in the car. Here the signals are amplified and filtered before being conducted to the Recorder, where they are instantly written in ink on paper. The record is therefore ready for interpretation within twenty seconds or less after the gun is fired. If successive records are desired, they may be taken at intervals of about thirty seconds, as the gun may be re-loaded for a second shot while the first one is still being recorded.

If the recording tape is permitted to run for a sufficient period of time, "multiple" fluid reflections, caused by successive travel of the sound wave between the well head and the fluid surface, will be recorded until the energy from the shot has been completely dissipated. (Illustrated by Record 1). These "multiple" reflections are sometimes helpful in the interpretation of records because of the similarities which appear at repeated intervals, or in cases where minute changes in the fluid level must be detected.

COMPUTATION OF RECORDS

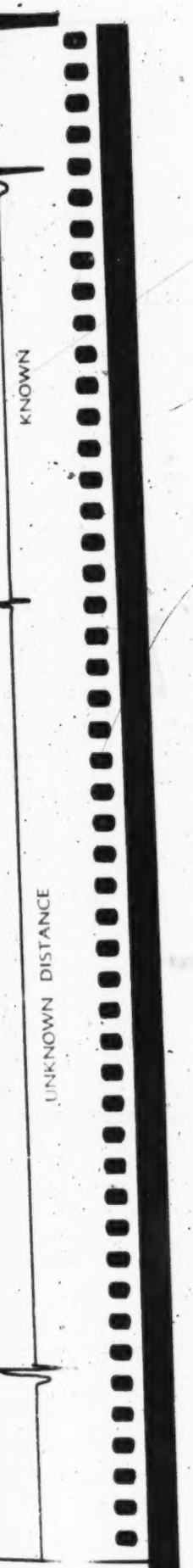
In the normal use of ECHO-METER equipment, the gun will be fired into the casing annulus. Therefore, each joint of casing and tubing exposed above fluid will tend to slightly obstruct the sound wave as it travels downward, and will cause small impingements to reflect back to the microphone at the casinghead. Since the magnitude of these reflected waves is dependent upon the percent change in cross-sectional areas of the annulus, it can be seen that reflections from casing joints are inferior in magnitude, or signal strength, to those caused by tubing couplings, and therefore will not be discernable. Thus, each of the stronger reflections caused by tubing collars is readily apparent on the ECHO-METER record, and the depth to fluid in the hole is obvious upon inspection of the tape.

Under average conditions, the depth to fluid can be interpolated to the nearest 0. 1 of a joint. Long subs at the top are usually indicated, and a tubing string of mixed joints wil normally show the relative joint lengths and sizes. (Illustrated by Record 2).



Record 2

Gives the fluid level below the tubing collars and the liner top. Note the 9 joints of short tubing in the top of string.



Record

Whenever the fluid-level is below some known well depth marker, such as a flow-valve, tubing catcher, or liner top, no appreciable error is involved if depths are computed by proportional measurements of record lengths, as:

$$\frac{\text{Length of record to Catcher}}{\text{Length of record to Fluid}} = \frac{\text{Depth to Catcher in Feet}}{\text{Depth to Fluid in Feet}}$$

There are certain field conditions whereby a "calibration" measurement of well velocity may be advantageously used to give the fluid depth. A simple application of such procedure would be on a gas well not equipped with tubing or siphon. Then, a float or other large object to serve as a reflector can be lowered on a line some known distance, say 100', into the well. In the absence of tubing or casing collars, the ECHO-METER record will still show a "shot point," a "calibration" reflection from the float, and a "fluid" or its equivalent reflection from a deeper part of the well. By proportional record measurement, as explained above, the "fluid" can then be located directly in feet. Among other applications, this procedure can be used to follow acid down the hole when treating gas wells, and it will eliminate any danger of damage to a measuring line because of fluid heading. (Record 3).

In cases where tubing, or other well conditions would prevent the easy use of a wire line, a coil of hose or a copper tube of known length can be attached to the Casinghead Unit at the microphone. This hose is purged of air and allowed to fill with well gas. If the hose contains gas of the same composition and pressure as does the casing annulus, it will therefore, in effect, transmit sound at the same velocity. Strong signals arriving at the microphone are recorded in the conventional manner. These same signals are then recorded a second time after passing through the known "calibration" distance. The record is computed by direct comparison of its known and unknown lengths.

With careful work "calibration" apparatus is limited in accuracy to about ± 1% of the fluid depth. However, its use will give consistent results independent of tubing records, and the procedure affords an approximate check on tallys of doubtful accuracy.

Record 4

Indicates the presence of external gas lift flow-valves. Similar results are obtained by shooting inside the tubing when casing flow installations are used.

USES OF FIELD DATA

The most common and most simple type of ECHO-METER data is a single fluid-level determination. (Record 1). This can usually be completed in less than half an hour per well and will show much about the efficiency of pumping or gas-lifting equipment. Such defects as gas locking of the pump, improper pump submergence, or inadequate equipment are easily discernible, and by continuing the fluid-level studies, effective cures can be devised.

On a gas-lift installation, the fluid-level in the casing is readily determined, and the number of external flow-valves exposed above the fluid are shown on the ink record. Such ECHO-METER data are helpful in determining the proper valve spacings and in enabling the operator to watch his well's flowing performance from the service. (Record 4).

BUILD-UP STUDIES

A series of ECHO records, obtained at the proper time intervals, will plot in a smooth fluid build-up curve. When conducting such studies with the ECHO-METER, numerous wells may be worked at the same time, for the instrument is not tied-up on one well as is the bottom hole pressure recording gauge. Likewise, all data are available immediately for interpretation, and tests can be discontinued or extended on various wells according to their individual behaviours.

BOTTOM-HOLE PRESSURES

Bottom-hole pressures can be computed from ECHO-METER data, with a great saving of time and money in the instances where a pressure bomb cannot be easily put into the well. Static, or shut-in bottom-hole pressures can usually be determined from a single ECHO shot, but flowing or pumping pressure studies are conducted in a different manner and multiple fluid-level determinations are normally required.

The bottom-hole pressure is the sum of the casing-head pressure (P_h), the weight of the gas column (P_g), and the weight of the fluid column. The weight of

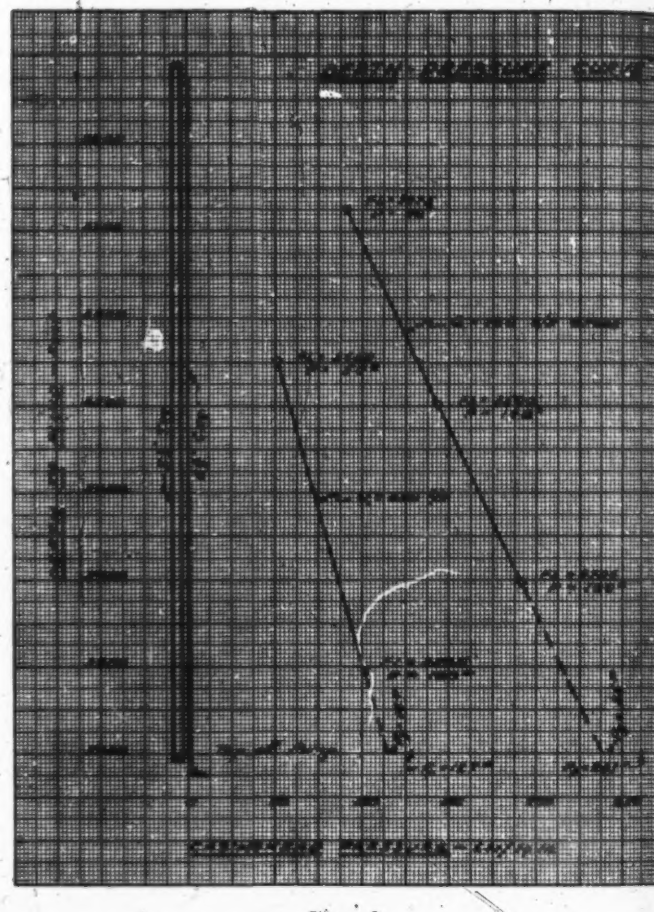


Figure 1

At any constant rate of production, a plot of equilibrium Fluid Levels vs. Casinghead Pressures will be a straight line. Extrapolation of this line to datum (in this case the pump) will show the casing pressure which, if reached, will maintain the fluid level in equilibrium at that point. Then the subsurface pressure at the pump (P_p) becomes equivalent to the total pressure of the gas above datum, or to the value of the extrapolated casinghead pressure plus the weight of the theoretical gas column (P_g).

the gas column can be determined if its length, specific gravity, average temperature, deviation from Boyle's Law, and surface pressure are known. (See charts inside back cover). The weight of the fluid is equal to its height (h) times the average density (d). Mathematically, the bottom-hole pressure may be expressed:

$$P_{bh} = P_h + P_g + hd \qquad (1)$$

The pressure bomb graphically records the total maximum pressure at any desired datum, but in ECHO-METER work the component parts of the total pressure are measured and the sum is computed mathematically, as all the factors involved are technically subject to individual measurement.

The pressure on the well casinghead can be gauged at the time of the shot initiation. The ECHO-METER record obtained is itself a measure of the length of the gas column. The specific gravity of the casing gas is easily and quickly determined with a portable measuring apparatus. (In ordinary field operations, the effects of temperature, deviation, etc., are of minor importance.) By subtracting the depth to fluid from the depth to the desired pressure datum, the height of the fluid column exerting pressure will be obtained. Substitution of the observed valves can then be made in equation (1).

In computing shut-in subsurface pressures, the average fluid density is generally known from previous experience and can be correctly assumed. If gradients are needed at different rates of production, measurements can be plotted for the changes in equilibrium fluid height at two or more different casinghead pressures and an extended line drawn through these points—thereby determining the casing pressure necessary to depress the fluid to any desired depth. (Illustrated by Figure 1.) When the fluid has been thus theoretically removed above the datum, the bottom hole pressure must be in equilibrium with the total pressure of the gas above. Therefore, the weight of the theoretical gas column at desired depth plus the extrapolated casinghead pressure at that depth will equal the datum pressure at the given production rate.

COMPUTATIONS FOR "WET" WELLS

Since the accuracy of ECHO-METER bottom-hole pressure calculations is dependent upon accurately determining the average density of fluid in the hole, it would appear that large quantities of water produced with the oil would cause the computations to be in error. At all producing rates where an appreciable draw-down of the fluid is obtained, however, the errors are minimized and nearly always are negligible for all practical considerations.

In a great majority of fields an appreciable separation of water from the oil usually takes place in the casing annulus, and a separation of the fluid into its components occurs when fluid equilibrium is reached at a given production rate. Since under this condition the pump is removing fluid at the same rate it is flowing into the well, the fluid below the pump is essentially of the same composition as that leaving the formation. In the annulus above the pump, where direct flow of fluid is not taking place, a quiescent condition will exist which permits gravitational seperation if the oil-water mixture is not too stable. The water and much of the bottom settlings will then be carried away by the moving fluid stream, leaving a measured column of fluid substantially of the same density as clean oil. The pump is then shut-down for the desired period, after which the amount of fluid build-up is determined.

When wells produce gas, the casing should be shut-in and the gas pressure allowed to build up to its highest practical value prior to shutting-down the pump, under which conditions the fluid height is determined. The gas pressure will cause the fluid-level to be as near the pump intake as possible, and thereby minimize any cumulative errors in computed density. Keeping the casing shut-in, the pump is then shut-down for the desired period, and the fluid-level again measured.

Fluid gradients are computed assuming that the fluid which was over the pump at the time it was shut-down was all clean oil. Likewise, the fluid which entered the hole during the time the pump was down is assumed to be of the same composition as that produced from the well while in an equilibrium condition.

Under certain conditions the pumping fluid-level may be omitted and the entire shut-in fluid column considered to be of the density of the oil-water mixture produced by the well. This will give an approximate bottom-hole pressure if the water percentage is not too high and if the fluid level can be depressed

almost to the pump before shutting in the well. For example, the density of clean oil produced will probably not run less than 30 lbs. sq. in. 100 ft. while the density of salt water will be approximately 45 lbs. sq. in. 100 ft. The maximum difference in the weight of a fluid column composed entirely of oil and one composed entirely of water is about 15 lbs. sq. in. 100 ft. Then in a hundred foot column of such fluid which contains one percent water the weight will be 0.15 lbs. greater than an equal column of clean oil.

It can readily be seen from these figures that, if the fluid column above the pump before the well is shut in is short, the resulting error in bottom hole pressure will not be large. For example, if there are 100 ft. of fluid above the pump before the well is shut-in and if the well is making ten percent water, the error in computed bottom-hole pressure will be only 1.5 lbs. sq. in.

WELL POTENTIALS AND THE PRODUCTIVITY INDEX

A calculated potential may properly be considered as a theoretical quantity, which represents the amount of oil a well would produce if the fluid could be taken from the well bore as fast as it entered. The ultimate capacity, or **theoretical** potential (Q), of a well would be obtained when the back pressure on the face of the producing formation was reduced to zero. Thus, the greatest pressure differential would exist between the reservoir (P_r) and the bore hole (P_{bh}), which would cause the fluid to enter at a maximum rate. Hence

$$Q = K(P_r - P_{bh}) \qquad (2)$$

Since Q is a function of the back pressure and is determined by that alone, it follows that if P_{bh} could be reduced to zero, Q would reach a maximum, which is the condition theoretically obtained in potential computations. Likewise, when the well is shut-in, $Q = 0$ and P_{bh} approaches equality with P_r. K is a constant of proportionality depending upon the dimensions of the system, and is proportional to the sand permeability. It is considered as a Productivity Index of the well, and is defined as "the barrels per day of gross liquid produced per pound per square inch pressure-drop at a specific subsurface datum."

Any condition tending to change the productive capacity of the well is indicated by a change in the

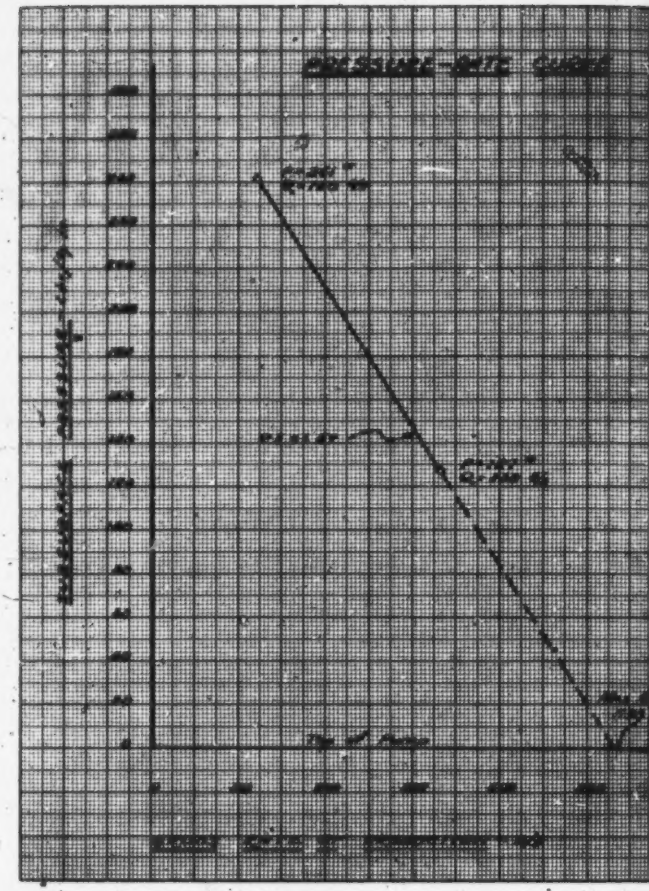


Figure 2

Datum pressures existing at various rates of production fall in straight line when plotted against their rates. The slope of th line determines the Productivity Index of the well; extrapolati shows the maxidm theoretical producing rate (Q), or potenti obtainable at the selected datum.

Productivity Index. A decreasing productivity w be obtained when the "gross production per pou drop in bottom-hole pressure" decreases. This co dition may be caused by increasing water, a decrea in effective permeability of the oil formation a jacent the well, or by drainage interference from of set wells. In some cases an increased productio factor may be obtained, especially if the well is clea ing out or channeling. Periodic measurements this index are a vital necessity in keeping a clos check on well performance. The decline of a well potential and changes in its producing condition can be intelligently followed, and in many case controlled, by the use of fluid-level data.

When wells have an ability to produce more flui than their equipment will handle, the old type physical pump or open-flow test is an unreliable in dex of capacity, as well as grossly expensive and e wasteful of reservoir energy. Such a test is merely demonstration of well equipment, and the outco m

o depends chiefly upon the size of tubing and or pump stroke employed. Some salient advantages of an ECHO-METER potential over a capacity physical test are:

1. Production rates which are harmful to the well are avoided. Reservoir equilibrium is disturbed a minimum, and less water is pumped during test.
2. A substantial back pressure is kept on the formation at all times during the test. This helps to prevent water coning and to alleviate "sanding-up".
3. Tests can generally be taken with regular well and field equipment. It is not necessary to install larger tubing, pumps, rods, and lead lines.
4. Less oil is produced during the test, requiring less tank storage.
5. Measurements can be made at convenience during regular work tours and do not need to upset labor schedules.
6. The actual cost of the test will be less. The service charge per well is nominal, and there are no "contengencies" and expensive break-downs of equipment to be feared. On pumping wells, no rods must be pulled in order to attach the instrument.
7. An accurate comparison between wells of their indicated producing abilities is obtained. "Loading" a hole with oil or permitting the shot hole to fill does not increase or alter the size of the potential as measured.
8. A Productivity Index of the well can be calculated from the ECHO-METER field data. Indices taken periodically will give a picture of the value of the well for tax and depletion estimates.
9. Comparative Indices can be used for approximating ultimate recoveries and economic limits. Such studies, when made in a new and undefined field, are invaluable to the land and exploration department.

Wh computing well potentials, measurements are tal at **low rates of production,** and the well's indicat performance at the higher rates is calculated from these data. A graph of experimental values with bottom hole pressure (P_{bh}) as ordinate and rate of production (Q) as abscissa will approach a straight line. Such a graph is called a "pressure-rate" curve (Figure 2), and when extrapolated to the Q intercept, i.e., the value of Q for $P_{bh} = 0$, yields the **theoretical** maximum rate of production since $P_{bh} = 0$ corresponds to a minimum back pressure on the formation face, (Equation 2). The negative slope of the pressure-rate curve is the Productivity Index.

The manner of conducting ECHO-METER potential tests varies, but it is dependent largely upon the gas-oil ratio of the well and upon the performance of the pumping equipment. In all cases the factors involved are bottom-hole pressure vs. different rates of production, and the method of measuring subsurface pressure determines the test procedure.

POTENTIAL MEASUREMENTS OF GAS-FREE WELLS

In wells operating at atmospheric pressure and which make little or no gas, the pressure on the fluid surface will be merely the weight of the gas column and has a negligible effect on the fluid-level. The height of the fluid within the well (which in this case is equivalent to the bottom-hole pressure) is then a function of the production rate only. Measurements therefore need be conducted only to determine the effects of the production rates upon the fluid height.

If the resulting values of equilibrium fluid height are plotted against their corresponding rates of production, a "draw-down" curve is obtained, (Figure 3), which extrapolated to zero fluid height yields the **theoretical** maximum rate of production, (Equation 2). The slope of the "draw-down" curve determines the Productivity Index of the well, which may be considered in this case as "gross production per foot of fluid draw-down".

Of converse relationship is the "Input Index" of a well, which is a measure of the formation's capacity for assimilating fluid. Such liquid capacity measurements are important in developing salt-water disposal projects, and observation of changes in the Input Index, indicating the probable formation of salt at the sand face, will aid in designing proper surface treatments for the water.

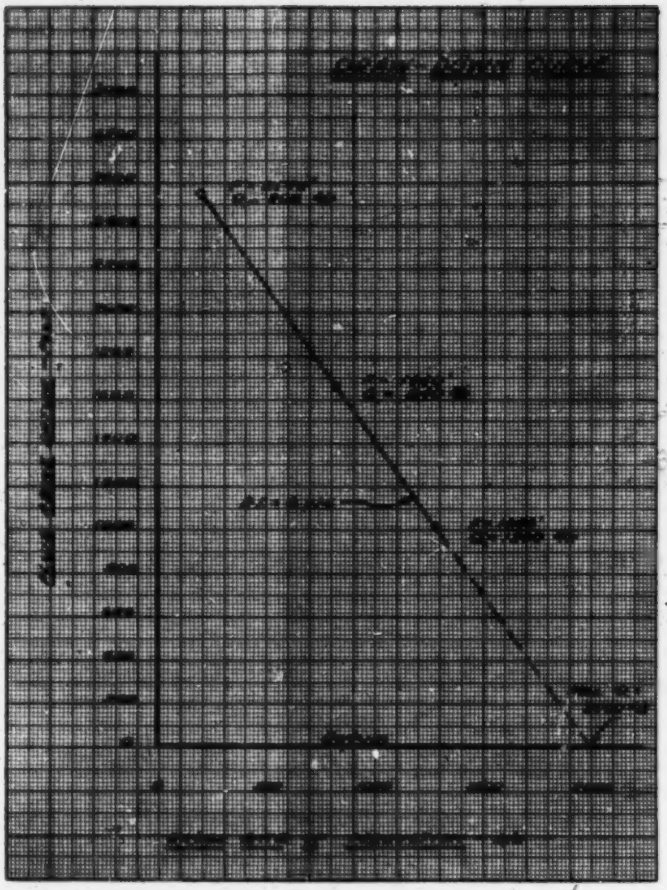


Figure 3

In gas-free wells, the height of fluid in the hole is proportioned to the rate of withdrawal. The negative slope of this "Draw-Down" curve is the Productivity Index, defined as "barrels per day per foot of fluid produced at equilibrium conditions." The maximum indicated potential (Q) is determined by extrapolation of the curve to datum, which is theoretically equivalent to withdrawing all the fluid from the well above this point.

POTENTIAL MEASUREMENTS ON HIGH GAS-OIL RATIO WELLS

When wells produce gas, the effects of the gas pressure on the fluid column must be determined, in addition to the effects of production rates. The effects of gas can be most easily observed by keeping the production rate constant, and measuring the changes in fluid-level at various casinghead pressures, as previously described. (See Figure 1). Thus, the bottom-hole pressure at a given production rate may be determined, and a "pressure-rate" curve drawn after two or more sets of such data are obtained (See Figure 2).

PRESSURE MAINTENANCE AND RE-PRESSURING

In large operations where it is desired to properly curb withdrawal rates from the individual wells and thereby to maintain the reservoir pressure at a uniform maximum, periodic detailed well studies are necessary. The same control is desirable when initiating and conducting reservoir re-pressuring programs. In both cases, ECHO-METER has been an invaluable guide successfully employed under widely diversified field conditions. Pumping and flowing wells may be taken alike, and due to the economy of the service, studies may be continued throughout the declining years of a field. This economy has enabled many projects to show a profit where otherwise the earnings would have been doubtful.

EVALUATION STUDIES

With the advent of proration, production men are seriously pressed for real values to sustain their holdings. ECHO-METER will assist them, for it embodies the simplest method and the fastest and most economical equipment yet developed for determining subsurface conditions in producing fields. It enables detailed studies to be conducted over large areas where heretofore only "key wells" could be measured and their averages drawn. ECHO-METER studies can be conducted in a short period of time, making the data truly relative, whereas old methods of measuring would take weeks or months in a large area and thereby rob the data of much significance.

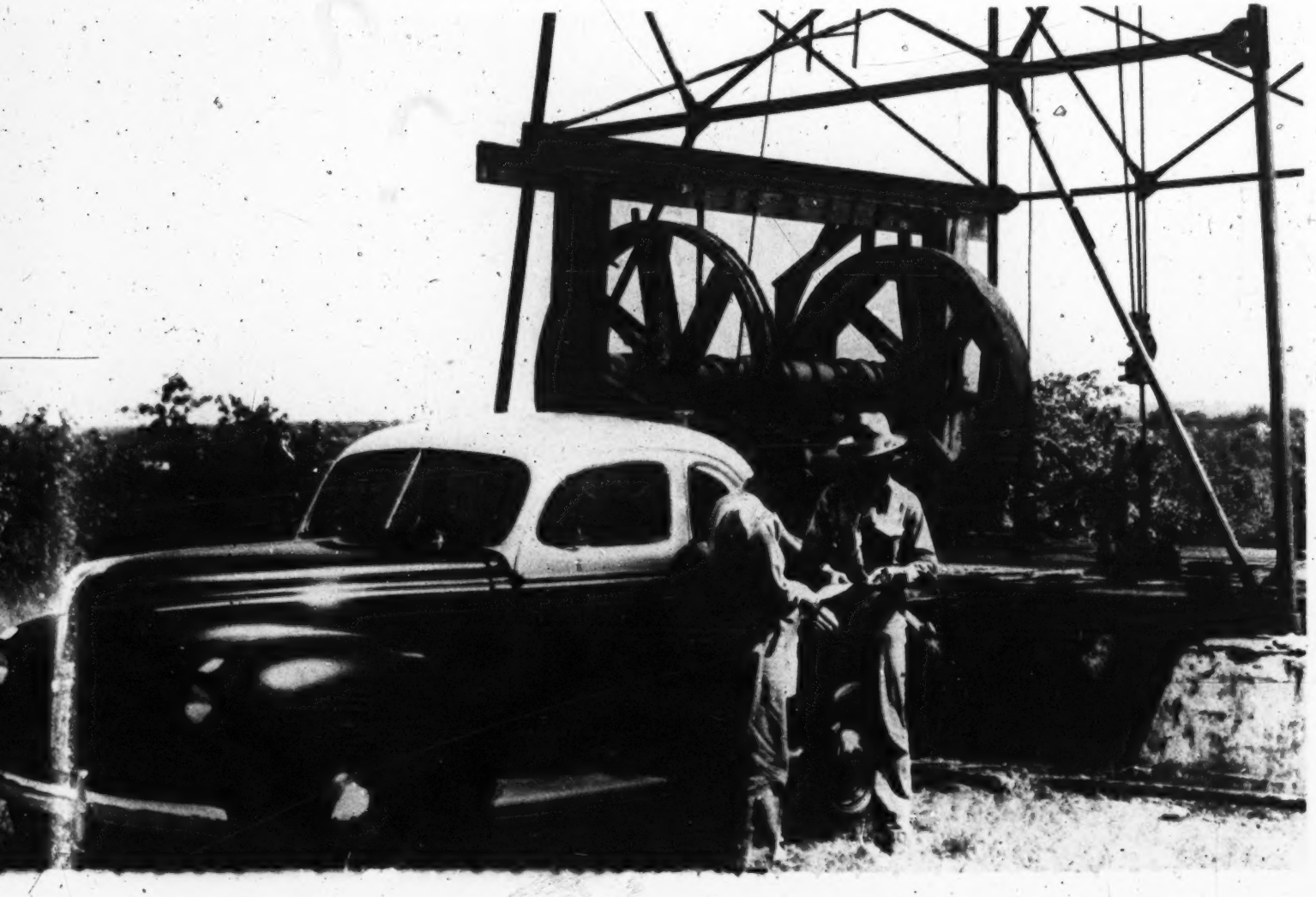
The Productivity Index, when plotted as a decline curve against accumulative production, becomes valuable in estimating ultimate recoveries and economic limits. Isobaric maps showing lines of equal bottom-hole pressure can be compiled, normally expressed with reference to a common datum plane. If two sets of contours are plotted, showing: (1) shut-in (static) bottom-hole pressure and (2) pumping equilibrium bottom-hole pressure at some given rate of production, these isobar maps will correspond to the Productivity Indices of the wells, and will give vital information on areas of higher permeability in the field. Such data make it possible for development work to be done in a better engineering manner, and this phase of the work grows in importance as the trend toward unit control of producing properties increases.

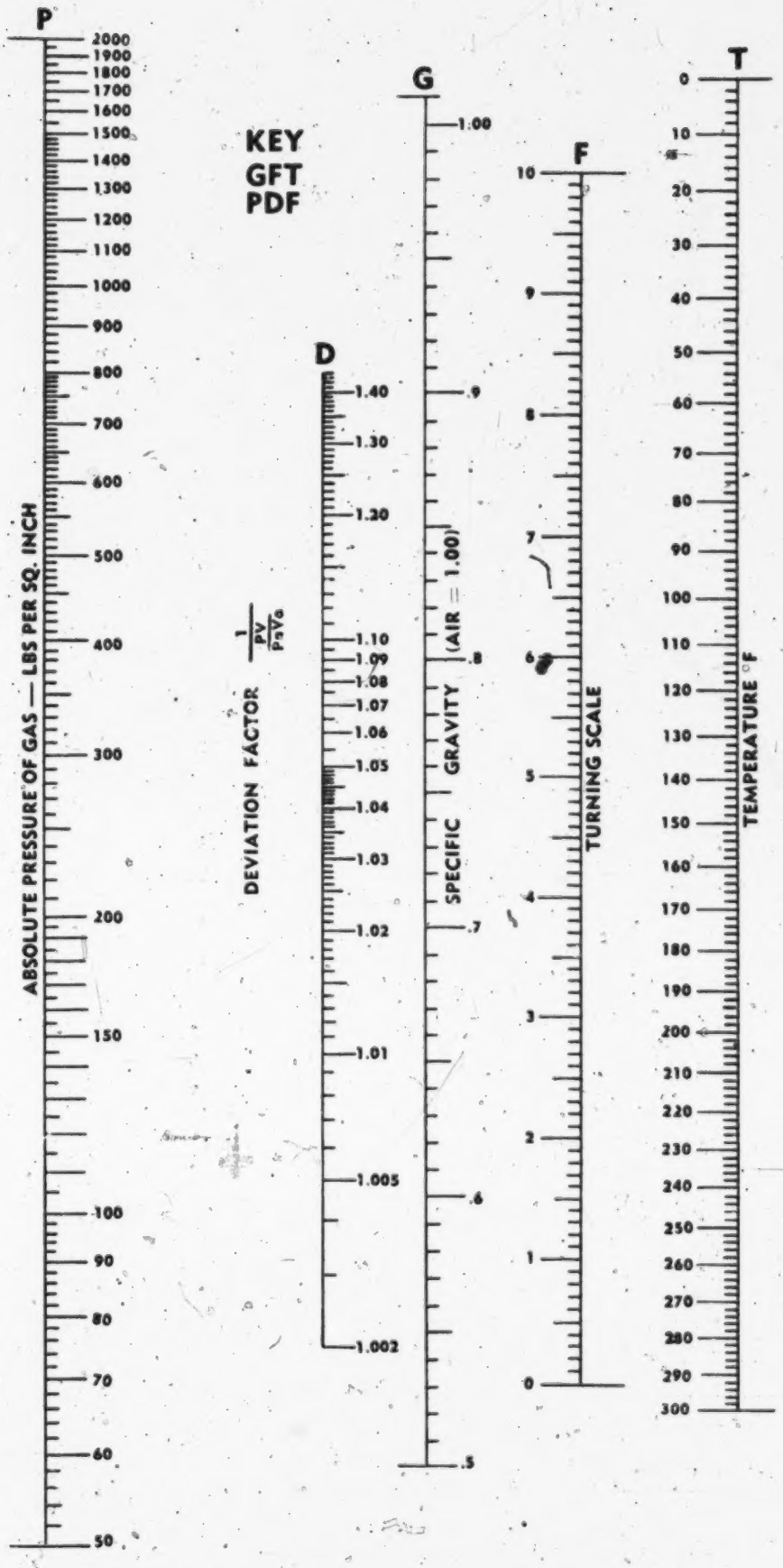
MISCELLANEOUS APPLICATIONS

Numerous occasions may arise in the conuct of drilling and exploration programs here the ECHO-METER will conveniently nd economically serve. By employing reections from either inside or outside the rill pipe, or some form of the "calibration" ethod of measuring, the fluid-level could e closely approximated in a hole which had lost circulation" of the drilling mud. In ases where flush joint drill pipe is used, emporary "reflectors" may be securely atached on the pipe at known intervals, and he fluid depth thus determined. In this vay, the ECHO-METER will aid materially n planning and in performing the necessary ement job.

In well cementing or acidizing operations, when fluid returns cannot be obtained at the casinghead, or where packers are employed, it is possible to directly and immediately measure minute changes of fluid-level in the casing annulus while the servicing operation is being performed. Thus, volumes and pressures can be computed just the same as if surface returns were had. Such measurements of the fluid-level can be made at desirable intervals by a sonic instrument under conditions which would be impractical for other types of measuring devices, and the value of an instantaneous pen-and-ink record of the fluid-level behaviour is readily apparent.

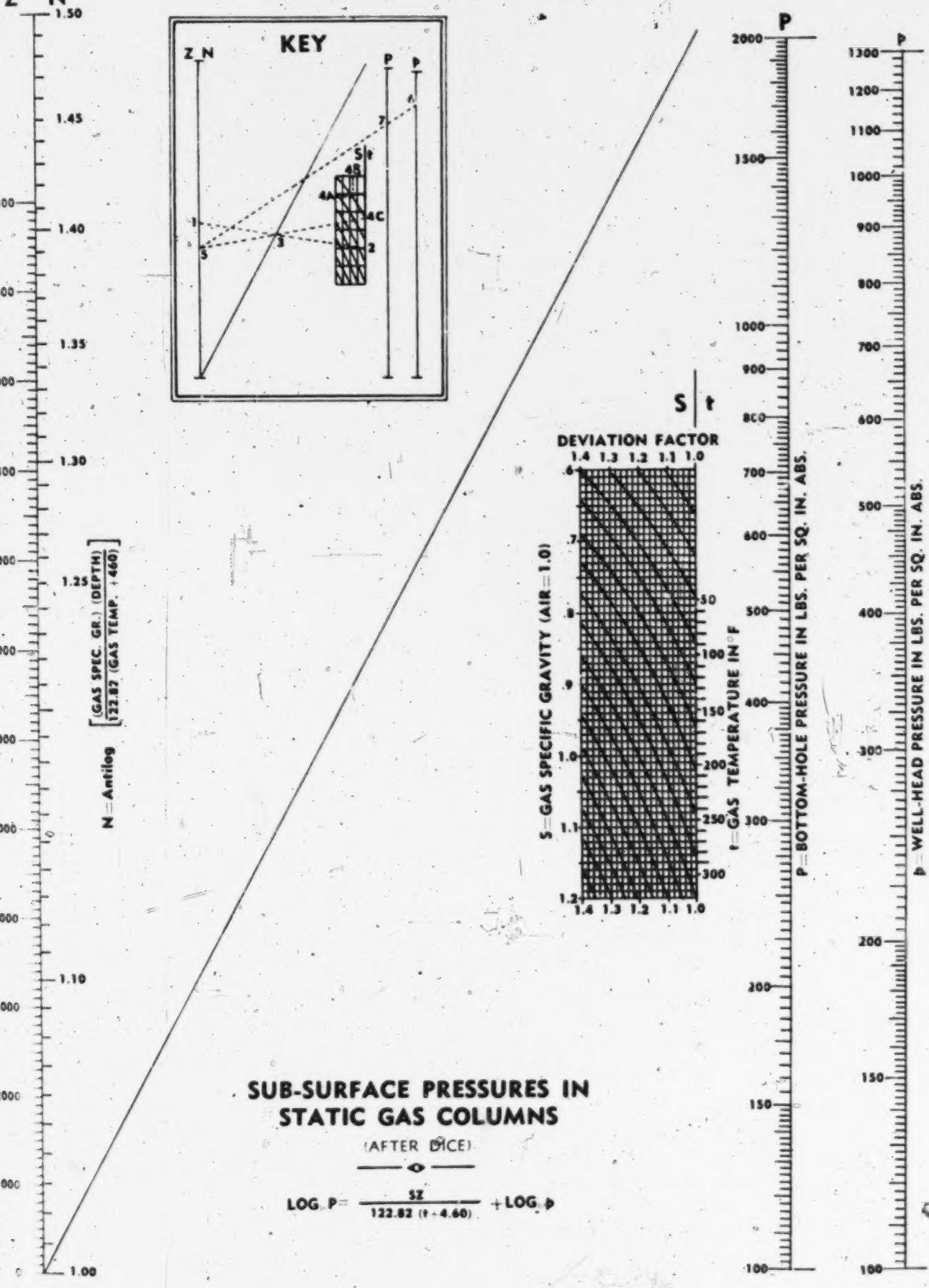
Discussing Echo-Meter Results with the operator





BOYLE'S LAW DEVIATION FACTORS FOR CO₂ AND AIR FREE PETROLEUM GASES

Volume at 14.73 #/□" Absolute and 60° F =
Observed Volume × Deviation Factor



SUB-SURFACE PRESSURES IN STATIC GAS COLUMNS

(AFTER DICE)

$$\text{LOG } P = \frac{SZ}{122.82\ (t + 460)} + \text{LOG } p$$

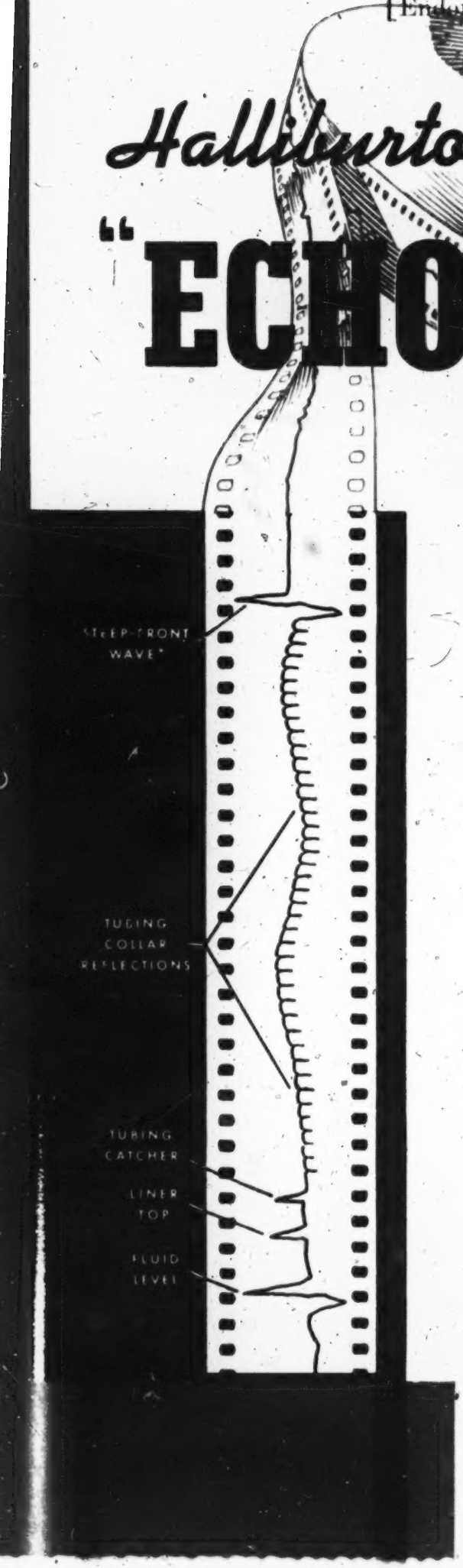
[Endorsed]: Filed Oct. 6, 1942.

Halliburton

"ECHO-METER"

(TRADE MARK)

for accurate fluid level determinations

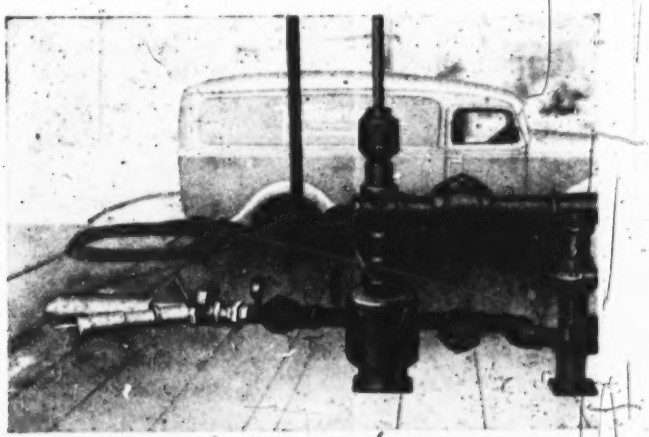


From ECHO-METER measurements of fluid levels in a well, it is possible to more accurately plan cementing plug-back jobs; to compile bottom hole pressure information for determining the potential and productivity of a well; to determine proper pump submergence, gas locking of the pump or adequacies of pumping equipment.

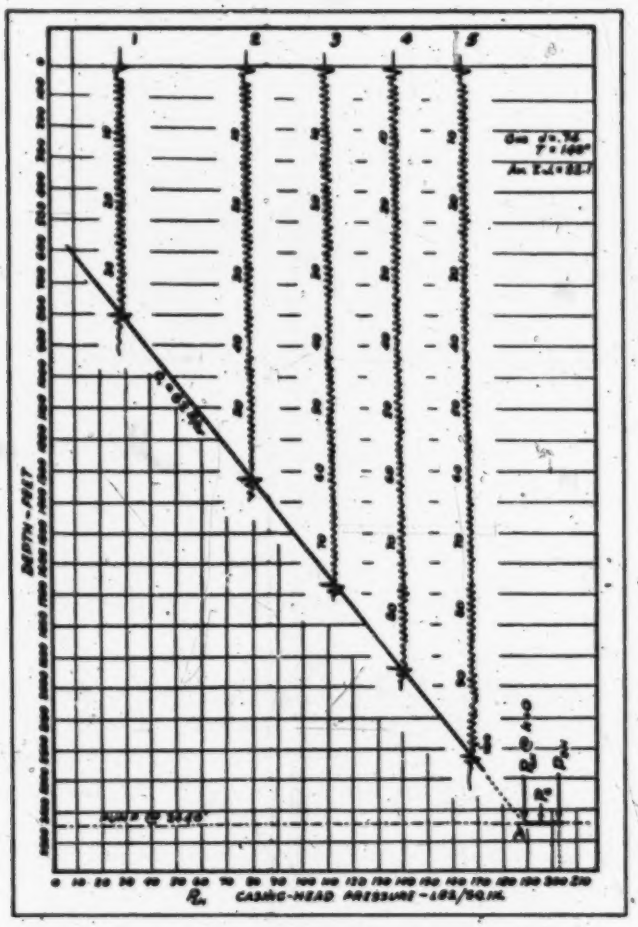
Location of the Fluid Level is obtained by recording the time required for a Steep Front Wave* to travel from the casing head to the fluid, and return. In addition to the reflections from the fluid level, other reflections are obtained from tubing collars, tubing catchers, and liner tops, providing a complete record of the internal conditions in the well.

The ECHO-METER Recorder* is of the newest direct-writing type. It gives an immediate ink record and eliminates the delays of photographic recording and developing. Utmost rapidity in making fluid level shots results in measurements of highest accuracy, as the small changes in fluid level may be followed.

*Method and apparatus patents are pending, covering all important phases of the ECHO-METER system and apparatus.



ECHO-METER Connected to Casing-Head



Example of Bottom Hole Pressure Determination by ECHO-METER Fluid Level Measurements

Bottom hole pressure measurements for any given rate of production are rapidly made by measuring the changes in equilibrium fluid height at two or more different casing head pressures—thereby determining the pressure necessary to depress the fluid to the desired depth. The illustration at top of the page shows the ECHO-METER records obtained for five different casing head pressures, and the computed bottom hole pressure at that given rate of production. The weight of the gas column, at the desired depth, is added to the casing head pressure, to give the total pressure necessary to force the fluid to that depth. When the height of fluid is theoretically zero, then the bottom hole pressure must be in equilibrium with the total pressure of the gas.

The bottom hole pressure is the sum of the casing head pressure (P_{ch}), the weight of the gas column (P_g) and the weight of the fluid column. The weight of the fluid is equal to its height (h) times the density (d). Mathematically the bottom hole pressure may be expressed:

$$(1) \quad P_{bh} = P_{ch} + P_g + hd$$

The ultimate potential or maximum production of the well is obtained by plotting a pressure vs. rate curve, i.e., plotting the bottom hole pressure versus different rates of production and then extrapolating the curve to zero bottom hole pressure. As shown by Equation (1) the maximum production will be obtained when P_{bh} is zero, since then the entire reservoir pressure is being utilized to drive the oil into the well. The productivity index is obtained by measuring the slope of the pressure-rate curve.

IMPORTANT OPERATION NOTES

1. All ECHO-METER measurements will be conducted by our trained operators. Due care and caution will be exercised, but we do not assume any liability for damages.
2. A readily accessible 2" pipe connection into the casing head shall be provided by the client. If the well is under pressure, a 2" gate or plug valve shall be installed at the casing head.
3. All manipulations at the well, such as opening or closing valves on gas or oil lines, changing pipe connections, changing pumping speeds, etc., shall be done by employees of client. The wells and their connected field equipment shall at all times be under the complete jurisdiction and control of the client. The client will furnish a man to be at the well during Fluid Level Measurements.
4. Gauging and reporting production, determining specific gravity of the gas, water content of production, and other control tests will be done by the ECHO-METER engineer upon request of the client. Charges for this work will be the same as those prevailing throughout the well measurements.

PLAINTIFFS' EXHIBIT No. 8-A

ECHOMETER FIELD DATA

Halliburton Oil Well Cementing Company
Duncan, Oklahoma

Company—Surf Associates Well—State # 1
Field—Huntington Beach

WELL DATA

Total Depth—4992 Plug Depth .....
Water String 8⅝ 36# Cemented—4463
Liner Size—5¾ 26# Length—564
Top of Liner—4428 Landed—4992
Perforations: From—4479 To—4992
Perforations: From .....To .....
Perfs: Size and Type—80 M - 16 R - 6" C Shop
Tubing: Size 2½ US Length—4856
Tubing Size .....Length .....
Total Tubing Length—4846
Number Joints—157
Average Joint Length—30.85

.....
.....

First Catcher Depth—3335 Type .....
Second Catcher Depth..... Type .....
Pump Depth—4846 Pump Size—2½x1¾x12
Pump Type—Axelson TL Gas Anchor: .....

.....

Gross Prod. B/D—70 Total Cut—12.5%
Net Oil B/D—62 Gravity API. Dry—25.5
Gas Fluid Ratio ..... Gas Gravity—.85
GasMCF/D .....
Static Fluid Level.....Date.....
Static Pressure.....Depth.....Date.....
Temperature..... Depth.....

TEST DATA

Date of Test—11/22/40

Time of Test	9:10	9:20	9:30	9:45	9:50	9:55
Pump Strokes/Min	15					
Length Stroke	28					

Casing Pressure	1#	1#	1#	1#	1#	1#
Fluid Level	4525	4525	4525	4525	4525	4525

By J. H. SHAW

Company..... Well..... Field.....

[Endorsed]: Filed Oct. 6, 1942.

PLAINTIFFS' EXHIBIT No. 8-B

ECHOMETER FIELD DATA

Halliburton Oil Well Cementing Company
Duncan, Oklahoma

Company—Surf Associates Well—State #1
Field—Huntington Beach

WELL DATA

Total Depth—4992 Plug Depth .....
Water String—8⅝ 36# Cemented—4463
Line Size—5¾ 26# Length—564
Top of Liner—4428 Landed—4992
Perforations: From—4479 To—4992
Perforations: From ..... To .....
Perfs: Size and Type—80 M - 16 R - 6" C Shop
Tubing: Size—2½ US Length—4856
Tubing: Size ..... Length .....
Total Tubing Length—4846
Number Joints—157
Average Joint Length—30.85

First Catcher Depth—3335 Type .....
Second Catcher Depth ..... Type .....
Pump Depth—4846 Pump Size—2½x1¾x12
Pump Type—Axelson TL Gas Anchor: .....

Gross Prod. B/D—71 Total Cut—12.5%
Net Oil B/D—62 Gracity API. Dry—25.5
Gas Fluid Ratio .....Gas Gravity—.85
GasMCF/D .....
Static Fluid Level.....Date.....
Static Pressure..... Depth..... Date.....
Temperature..... Depth.....

TEST DATA

Date of Test—11/25/40					
Time of Test	9:15	9:30	9:45	10:00	10:10
Pump Strokes/Min	15				
Length Stroke	28				
Casing Pressure	60#	60#	60#	60#	60#
Fluid Level	4745	4745	4745	4745	4745

.....
.....
.....

By J. H. SHAW

Company..... Well..... Field.....

[Endorsed]: Filed Oct. 6, 1942.

PLAINTIFFS' EXHIBIT No. 8-C

ECHOMETER FIELD DATA

Halliburton Oil Well Cementing Company
Duncan, Oklahoma

Company—Surf Associates Well—State #1
Field—Huntington Beach

WELL DATA

Total Depth—4992 Plug Depth .....
Water String—8⅝" 36# Cemented—4463
Liner Size—5¾ 26# Length—564
Top of Liner—4428 Landed—4992
Perforations: From—4479 To—4992
Perforations: From .....To .....
Perfs: Size and Type—80 M - 16 R - 6" C Shop

Tubing: Size—2½ US Length—4856
Tubing: Size ..... Length .....
Total Tubing Length—4846
Number Joints—157
Average Joint Length—30.85

.....

.....

First Catcher Depth—3335' Type .....
Second Catcher Depth ..... Type .....
Pump Depth—4846 Pump Size—2½x1¾x12
Pump Type—Axelson TL Gas Anchor: .....

.....

Gross Prod. B/D—162 Total Cut—12.5%
Net Oil B/D—142 Gravity API. Dry—25.5
Gas Fluid Ratio ..... Gas Gravity—0.856
GasMCF/D .....
Static Fluid Level ..... Date.....
Static Pressure..... Depth..... Date.....
Temperature..... Depth.....

TEST DATA

Date of Test—11/19/40

Time of Test	9:30	9:45	9:55	10:05	10:20	10:30
Pump Strokes/Min	17.2					
Length Stroke	42					
Casing Pressure	12	12	12	12	12	12
Fluid Level	4846	4846	4846	4846	4846	4846

.....

.....

.....

By J. H. SHAW

Company..... Well..... Field.....

[Endorsed]: Filed Oct. 6, 1942.

PLAINTIFFS' EXHIBIT No. 8-D

ECHOMETER FIELD DATA

Halliburton Oil Well Cementing Company
Duncan, Oklahoma

Company—Surf Associates Well—State #1
Field—Huntington Beach

WELL DATA

Total Depth—4992 Plug Depth .....
Water String—8⅝ 36 Cemented—4463
Liner Size—5¾ 26 Length—564
Top of Liner—4428 Landed—4992
Perforations: From—4479 To—4992
Perforations: From ..... To .....
Perfs: Size and Type—80 M - 16 R - 6" C Shop
Tubing: Size—2½ US Length—4856
Tubing: Size ..... Length .....
Total Tubing Length—4846
Number Joints—157
Average Joint Length—30.85

.....

.....

First Catcher Depth—3335 Type .....
Second Catcher Depth..... Type .....
Pump Depth—4846 Pump Size—2½x1¾x12
Pump Type—Anxelson TL Gas Anchor: .....

.....

Gross Prod. B/D—162 Total Cut—12.5%
Net Oil B/D—142 Gravity API. Dry—25.5
Gas Fluid Ratio ..... Gas Gravity .....
GasMCF/D .....
Static Fluid Level..... Date.....
Static Pressure..... Depth..... Date.....
Temperature..... Depth.....

TEST DATA

Date of Test—11/20/40
Time of Test 11:30 11:35 11:40 12:30 12:35 12:40
Pump Strokes/Min 17.2
Length Stroke 42

Casing Pressure	0	0	0	0	0	0
Fluid Level	4785	4785	4785	4785	4785	4875

By J. H. SHAW

Company..... Well..... Field.....

[Endorsed]: Filed Oct. 6, 1942.

PLAINTIFFS' EXHIBIT No. 9

Central Committee of
Calif. Oil Producers
Office of Oil Umpire
1160 Subway Terminal Bldg.
Los Angeles, California

SUBSURFACE PRESSURE TEST DATA

Potential Determination For Pumping Wells

(Information Confidential)

1134
Pumping F 14
6 5 40

Company—Surf Associates
Lease & Well No.—State #1

Field—Huntington Beach
Pool.....

AVERAGE PRODUCTION FOR PRETEST PERIOD

First 10 Days.....	111 B/D Gross	97 B/D Net	12.5% Total Cut
Last 3 Days	159 B/D Gross	139 B/D Net	12.5% Total Cut

CASING RECORD (Any Additional Casing Details Show on Separate Sheet)

Total Depth	4992 Ft.	Plug Depth	Ft.:	
Water String	8⅝"	36#	Cemented at	4463 Ft.:
Oil String	"	#	Landed at	Ft.:
564 Ft. of 5¾" 26# Liner			Top at	4428 Ft.:

TUBING RECORD

Size	2½"
	"
Pump Shoe at	4846 Ft.
Packer at	Ft.
Depth.....	4846 Ft.
.....	Ft.

Effective Perforations	Zone	Size & Type of Perforations
From.....4479 Ft. to.....4992 Ft.	.....	80 M - 16 R - 6" Shop
..... Ft. to..... Ft.	.....	.....
..... Ft. to..... Ft.	.....	.....

vs. Cranford P. Walker, et al. 643

Plaintiffs' Exhibit No. 9—(Continued)

PRODUCTION EQUIPMENT

Type of Pump—Axelson TL Pump Size—2½" Plunger Dia.—1¾"

Test	"A"	"B"	"C"	"D"	"E"	"F"
Date of Test	11/19	11/20	11/22	11/25		
Length of Stabilization Period, Hrs.	72	24	48	72		
Production Rate, B/D Gross	162	162	70	71		
Total Cut, %	12.5	12.5	12.5	12.5		
Net Oil Rate, B/D	142	142	62	62		
Gas Rate, MCF/D	32	25	28			
Pump Strokes per Minute	17.2	17.2	15	15	(No Static)	
Length of Stroke, Inches	42	42	28	28		
Casing Pressure, P. S. I.	12#	0	1	60		
Gas Column Weight P. S. I.	4	2	2	11		
Sonic: Total Pressure on Fluid Surface P. S. I.	16	2	3	71		
Sonic: Fluid Level, Ft.	4846	4785	4525	4745		
Sonic: Fluid Gradient in " Casing, PSI/Ft.						
Fluid Gradient 15¾ Casing, PSI/Ft.	0.309			0.309		
Recorder: Recorder Depth, Ft.						
Recorder: Pressure at Recorder, P.S.I.						
Recorder: Initial Tension of Recorder, P.S.I.						
Recorder: Temperature, °F						
Mean Formation Pressure, P. S. I.	24			90		

Plaintiffs' Exhibit No. 9—(Continued)

Oil Gravity (Dry) 25.5° API Gas Fluid Ratio.....Cu.Ft./Bbl. Gas Gravity .85

COMPUTED RESULTS

Minimum Mean Formation Pressure with Fluid Level at (Pump Shoe .....8 P.S.I.

Calculation: .....

$$\frac{162-70}{90-24}$$

Gross Productivity Index: .....1.4 Calculation: .....

Calculated Potential: .....184 B/D Gross.....161 B/D Net.....$(1.4\ (24-8)-\frac{162}{162})\ .875$

Potential Factor: .....182 B/D Gross.....159 B/D Net.....$(162\ (2-184))\ .875$

(For Recorder Method, Present Pressure and Production vs. Time Chart)

Remarks .....

.....

.....

Company Taking Measurements—HDWCO By—J. H. Shaw

Data Witnessed by..... Certified by..... Date.....

Potential Factor—159 Assigned for Month of Dec 1940

[Endorsed]: Filed Oct. 6, 1942.

PLAINTIFFS' EXHIBITS Nos. 10, 11, and 12
(Combined and Abridged)

PLAINTIFFS' INTERROGATORIES PROPOUNDED TO DEFENDANT AND ANSWERS

Now Come the plaintiffs, pursuant to Rule 33 of the Federal Rules of Civil Procedure, and propound the following interrogatories to be answered under oath by the corporate defendant by its officer or officers having knowledge of the facts, and with reference to each of said interrogatories the time period inquired of is the time period preceding the filing of the Bill of Complaint herein and subsequent to the dates of issue of the respective patents in suit herein.

1.

Is Plaintiffs' Exhibit 6 a folder published and distributed by or on behalf of the defendant?

Answer: Yes.

2.

Does Plaintiffs' Exhibit 6 correctly describe and illustrate those methods and apparatus, or any of them, admitted in Paragraph IX of the answer herein to have been employed by defendant for

(a) measuring the location of obstructions in wells;

Answer: Yes.

(b) determining in oil wells the fluid density;

Answer: No. The Exhibit No. 6 referred to

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

does not describe how to determine fluid density in oil wells.

(c) determining in oil wells the fluid pressure; and

Answer: Yes.

(d) determining the production capacity of oil wells?

Answer: Yes.

3.

If the answer to Interrogatory 2 is "no", with respect to any of the items (a), (b), (c) or (d), state in what manner the apparatus and methods used by defendant with respect to said "no" answer differs from the respective methods and apparatus described and illustrated therefor in Exhibit 6.

Answer: Exhibit No. 6 referred to does not describe how to determine item (b) of Interrogatory No. 2 and defendant does not know what methods and apparatus were actually used to determine item (b) of Interrogatory No. 2 in the few cases where such item has been determined. See answer to Interrogatory No. 4.

4.

If the answer to Interrogatory 2 is "no" with respect to any of the items (a), (b), (c) or (d), furnish to plaintiffs detailed description and drawings illustrating the method and apparatus employed to perform any of the items to which a "no" answer is made to Interrogatory 2.

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

Answer: Defendant does not know. As stated in the Answer filed herein (and in the Amended Answer), defendant admits that in a few isolated instances employees of defendant have determined fluid density or fluid gradient as, for example, in plaintiffs' Exhibits Nos. 8-A, 8-B, 8-C, 8-D and 9 herein. The practice has long since been discontinued and the records of defendant do not show what methods and apparatus were used. Defendant is informed and believes that such determinations were made only by J. H. Show, formerly an employee of defendant, now believed to be employed by the Division of Oil and Gas, State of California, 629 South Hill Street, Los Angeles, California.

5.

Are the methods and apparatus employed by defendant for locating obstructions in wells, as admitted in Paragraph IX of defendant's answer herein, correctly described and illustrated in the first five pages of the folder, Plaintiffs' Exhibit 6 herein?

Answer: Yes.

6.

If the answer to Interrogatory 5 is "no", furnish to the plaintiffs.

(a) a detailed description of and drawings illustrating the apparatus used and the manner in which it operates for

(1) creating the steep front sound wave;

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued).

(2) communicating said sound wave to the annular space between the tubing and the casing of a well;

(3) how the reflections from the obstructions are received and recorded;

(4) how the recorder tape is driven relative to the pen;

(5) how the filter operates and how it is adjusted to aid or suppress different frequencies.

Answer: Requires no answer.

7.

State whether or not the microphone, amplifier or recorder, or any of them, used by defendant is employed to secure clear records of the echoes from the tubing collars in a well and to suppress or eliminate other disturbances or noises.

Answer: Yes. Echoes of whatever nature in the well are recorded but the arrangement is such that external noises and disturbances are eliminated to a large extent. For example, striking the pipe with a hammer has little or no effect upon defendant's record.

8.

Are the records appearing on the fourth and fifth pages of the folder, Exhibit 6, correct examples of the records made by defendant on actual fluid level measurements made on wells?

Answer: Upon information and belief, yes. The

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

records and the entire Exhibit No. 6 were prepared by Dan Elam, now in the Army. It is possible that the records were slightly touched up before printing. The originals have not been located. The records in Exhibit No. 6 are believed to be correctly illustrative of defendant's actual fluid level measurements.

9.

If the answer to Interrogatory 8 is "no", state how the actual records differ therefrom and furnish typical true actual records or true copies of actual records showing

(a) the shot, tubing collar echoes, tubing catcher echo and fluid level echo;

(b) the shot, a "calibration reflection" and fluid level reflection.

Answer: In view of the fact that the answer to Interrogatory No. 8 is not positive, typical, true, actual records are attached hereto (Plaintiffs' Exhibits 11-A and 11-B). 11-A gives the information called for in item (a) of Interrogatory No. 9 and Exhibit 11-B gives the information called for in item (b) of Interrogatory No. 9.

10.

Does the defendant employ any means for filtering out noises or other disturbances differing in frequency or time period of reception at the microphone of the echoes from successive tubing collars in the well?

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

Answer: Yes, occasionally. Some of defendant's equipment in the field does not have filtering means. Other equipment has filtering means, but even then the filtering means is not always used.

11.

If the answer to Interrogatory 10 is "yes", describe in detail each and every method and apparatus the defendant employs to filter out said noises or other disturbances differing in frequency or time period and reception at the microphone of the echoes from successive tubing collars in the well.

Answer: The filter defendant employs is a conventional electrical system. Since the construction and operation of the filter may not be clear without the description of the entire electrical recording apparatus, a copy of defendant's Echo-Meter Field Manual accompanies these answers (Plaintiffs' Exhibit 11-C). In Exhibit 11-C, the filter circuit is shown on drawing No. 7506. The construction and operation is correctly and fully described in Exhibit 11-C, particularly beginning on page 13 thereof.

12.

If the answer to Interrogatory 10 is "no", describe how and by what apparatus records like Record 2 on Page 4 of Exhibit 6 are obtained by the defendant to show individual tubing collar echoes substantially undisturbed by other noises or frequencies.

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

Answer: Since the answer to Interrogatory No. 10 is partly in the negative, defendant answers Interrogatory No. 12 by stating that often there is not a great deal of difference between the record obtained when a filter is used and the record obtained when the filter is not used. The difference lies chiefly in the shape of the wave on the record. The apparatus employed and the method employed by defendant in obtaining records where no filter is employed consists merely of a hot wire microphone, an electrical amplifier and an electrical recorder, all as described in detail in Exhibit 11-C. The system excludes only noises external to the well. There is nothing which causes tubing collar reflections to be selected and recorded as distinguished from echoes from other obstructions in the well.

13.

Attached hereto is a drawing (now Plaintiffs' Exhibit 10-A).

(The interrogatory then included a long description of the apparatus shown in the drawing and its operation.)

Does the foregoing description and the sketch, (Exhibit 10-A), correctly describe and illustrate the apparatus employed by the defendant for measuring the location of obstructions in wells and the method employed by the defendant for measuring the location of obstructions in wells?

Answer: No, not accurately.

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

14.

If the answer to Interrogatory 13 is "no", then describe in detail and furnish drawings illustrating the differences between the apparatus and methods which are employed by the defendant and the method and apparatus described in Interrogatory 13.

Answer: A complete description with drawings of defendant's apparatus and method of operation is found in Plaintiffs' Exhibit 11-C.

Supplement to Answer: The drawing (Plaintiffs' Exhibit 10-A) correctly illustrates defendant's Echo-Meter diagrammatically except for the following:

A plug valve should be inserted between the elements 9 and 10.

A bleeder valve adapted to connect the interior of the device now marked 10 to the atmosphere, should be added.

A valve should be inserted between the parts marked 7 and 8.

The lead line for the numeral 28 should go to the pipe beneath this numeral, rather than to the valve 29.

The lead line for the numeral 10 should go to a point slightly above that illustrated, the gun being the cylindrical portion above the coupling.

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

The drawing, Plaintiffs' Exhibit 10-A, illustrates diagrammatically a cross section of a typical oil well including casing 1, tubing 2, at the lower end of which is a pump 3, operated by means of sucker rods 4 extending up through the pump tubing 2 and terminating at the upper end as a polished rod 5, to which power mechanism for reciprocating the sucker rods is connected. At the upper end of the casing 1 is a casing head 6, having an opening 7 to which is connected piping 8. Connected to the piping 8 is shown a casing head unit A, of the type illustrated in the second page of the folder, (Plaintiffs' Exhibit 6), this casinghead unit comprising a Y pipe fitting 9, to the vertical branch of which is coupled a gun mechanism 10, in which a cartridge may be located, and fired by an energized electrical solenoid 11 or by a mechanical trigger means. The gun unit A, with the parts identified, is shown in more detail in the attached drawing (Defendant's Exhibit 12-A), and in the attached photographs (Defendant's Exhibits 12-B and 12-C).

To the angle branch of the Y fitting in Plaintiffs' Exhibit 10-A and Plaintiffs' Exhibit 12-A, is coupled a butterfly valve 12 operated by a handle 13, in turn connected to a pipe fitting 14, to which is connected a pressure gauge 15 and an electric connection box 16. Surge chamber 17 comprising a hollow pipe closed at one end, is coupled to the fit-

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

ting 14, and between the surge chamber 17 and the fitting 14 is located a hot wire microphone 18, the construction of which is as illustrated on the drawing No. 7458 of Exhibit 11-C. The grid of the microphone is electrically connected to the connection box or plug 16. An electrical cable 20 extends from the connection box 16 to the transducer in box B, such as illustrated in the upper photograph on page 3 of the folder, Plaintiffs' Exhibit 6.

The transducer apparatus in box B includes an electrical amplifier and an electrical filter. The circuit connections of the amplifier are shown on sheets 1 and 2 (Drawings 7515 and 7531 of Exhibit 11-C). The electrical filter is illustrated on the drawing 7506 of Exhibit 11-C.

In addition to the apparatus illustrated in the drawing, Plaintiffs' Exhibit 10-A, there are several batteries. A 45-volt battery sends an electrical current through the grid of the microphone 18 and heats the same. Automobile batteries supply current to the amplifier and recorder units.

The structure of unit A is such that the firing of the gun or the echoes therefrom cause movement of gas through the grid of the microphone and this movement cools the grid. The grid is of such a nature that its electrical resistance varies with its temperature. Therefore, the electrical resistance of the grid circuit varies when the gun is fired and when the echoes come back from the well, and

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

these changes in resistance control the amount of current in the circuit.

Variations in the electrical current in the heating circuit for the grid of the microphone 18 are amplified by the electrical amplifier in the box B. The electrical amplifier in the box B is connected to an electrical recorder 22 which has a paper tape 23 driven by means of an electric motor at a uniform rate of speed, so that on the tape is recorded, in an amplified form, variations in electrical resistance of the grid of the microphone 18. Hence, the record on the tape 23 shows variations in gas movement through the microphone 18.

A push button 24 is employed to supply electric current through the cable 20 and wires 25 to the solenoid 11 to fire the cartridge in the gun. In some instances electrical firing is not employed and the gun is fired manually by pulling the trigger, or the equivalent on the gun. * * * The attached photograph (marked Exhibit 12-B) shows a mechanically fired gun (a Winchester salute gun). Some elements of the recorder are shown in detail in the drawing marked Plate III of Exhibit 11-C.

The electrical filter in the amplifier circuit in the box B is not always used. When used, it may be tuned to the frequency of tubing collar reflections by a control knob 26. The filter has nothing to do with the sound waves in the well, nor the movement of gas through the microphone 18. It is

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

used to select for the recorder certain electrical impulses passing from the microphone through the electrical amplifier in the box B. By the use of the filter, it is sometimes possible to make a clearer record of tubing collar reflections. The filter does not cause reflections from tubing collars and those from tubing catchers to be distinct. It does not make reflections from tubing catchers or from fluid surfaces any clearer.

The casinghead 6 may be provided with an outlet 27 from which extends a pipe 28, having a valve 29 by which gas within the well may be either prevented from escaping or may be permitted to escape at a desired rate by regulating the valve 29.

The operation of the apparatus is as follows:

The gun 10 is loaded with a blank cartridge, either a 10 gauge shot gun shell or a .38 caliber pistol shell. The selection of the size of cartridge depends upon the distance to the fluid to be located in the well. The approximate distance to the fluid is not always known initially. If it is thought that the fluid is relatively close to the surface, the smaller cartridge is used. If it is found that the fluid is not so close to the surface, the larger cartridge is used on the next shot.

The firing pin of the gun is cocked and held cocked by mechanism which is released upon energization of the firing solenoid 11 or by the trigger, depending upon what type of apparatus is used.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

The butterfly valve 12 is usually closed while the cartridge is fired, to prevent injury to the microphone 18, especially if the larger cartridge is being fired. The recorder motor is started to move the tape past the recording pen some time prior to the firing of the cartridge. The sound wave created by the firing of the cartridge causes some gas movement in the microphone 18 even when the valve 12 is closed, since the valve 12 is not air tight, so that the firing of the gun is recorded on the tape 23. The sound wave also passes down through the fitting 9 and into the annular space between the tubing 2 and the casing 1, through the opening 7 in the casing head. Successive reflections or echoes from tubing collars 30 cause gas movement through the microphone 18, which operates as described above to make a record on the tape 23 of the echoes from the tubing collars, the position of these echoes on the strip 23 being substantially proportional to the actual successive spacing of the tubing collars on the tubing 2 in the well.

Reflections or echoes from obstructions such as tubing catchers, the top of the liner, if there is a liner in the well, and from the fluid surface, also cause gas movement through the microphone 18 and, accordingly, are indicated on the tape 23, the place on the tape where such records are made being substantially proportional to the actual spacing of these obstructions in the well.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

The filter is never used on the first shot in a well. The record of the first shot shows the tubing collar reflections, but sometimes they may be made clearer. To make a better record, two things may be done. The filter may be connected into the circuit. The amplifier may be manipulated to increase the strength of the current supplied to the recorder. The selection of the filter setting is determined as follows:

Each Echo-Meter unit has its own electrical characteristics. Each well upon which it is used has its own characteristics, such as the kind of gas, the pressure of the gas, etc. Each Echo-Meter unit is calibrated and from the calibration chart, the operator can determine the setting of the dial 26 on the basis of data about the particular well obtained when the first shot is fired. A calibration chart for one Echo-Meter unit is attached hereto (now Exhibit 12-E).

If the operator desires to improve the record of tubing collar reflections, the dial 26 is set at the point indicated by the calibration chart for the frequency of tubing collar reflections recorded when the filter was not used. A series of records, each with a different adjustment of the knob 26, is never made. Where the filter is used at all, the position of the knob 26 depends only upon the calibration chart and the distance between tubing collar echo records obtained when the first (unfiltered) shot was fired.

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

The second step taken to improve the record of tubing collar reflections is to control the amount of amplification. This may be done during the making of the record. That is, the amount of amplification. (entirely independent from the filter circuit and knob 26) may be increased as the echoes from the well are being received. It may take several seconds for the echoes to return from the well and during this interval, the knob which controls the amplification may be moved manually, gradually, to increase the amplification. In this way the weak echoes from the deeper part of the well may be made to show up as well as the stronger echoes from the collars or obstructions nearer the surface.

15.

Does the defendant count the number of tubing collar echoes or reflections recorded upon the record tape between the record of the shot and the record of the fluid level reflection to determine the location of the fluid level?

Answer: Yes.

16.

Does the defendant measure the length of the record between the record of the shot and the record of the reflection from an obstruction, the location of which is known, and compare this length of record with the length of the record between the rec-

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

ord of the shot and the record of a reflection from an obstruction, the location of which is unknown, to determine the location of the unknown obstruction?

Answer: Yes, at times.

17.

State what compensation, if any, is made

(a) for the variation in the velocity of sound waves in one well under measurement from the velocity of sound waves in another well under measurement; and

Answer: None.

(b) for the average length of tubing sections in one well under measurement being different from the average length of the tubing sections in another well under measurement.

Answer: None.

18.

Has the defendant ever employed pipe connection between the casinghead of a well and the microphone of different lengths?

Answer: No.

19.

If the answer to Interrogatory 18 is in the affirmative, state the reasons for using such different lengths of pipe connections.

Answer: Requires no answer.

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

20.

Has the defendant ever used surge chambers such as that appearing at the left-hand side of the left-hand photograph on page 2 of the folder, Exhibit 6, of different lengths?

Answer: No, not on any one well. However, the surge chambers on defendant's different apparatuses are not always of identical length.

21.

If the answer to Interrogatory 20 is in the affirmative, state the reason for using surge chambers of different length.

Answer: The surge chambers on the different apparatuses are not identical. The variation in length of surge chambers was due merely to happenstance.

22.

Has the defendant ever placed a calibrating reflector in a well at a known location and then in making a fluid level measurement recorded the reflection from the calibrating reflector and the fluid level?

Answer: Yes, a few times. An object has been lowered in a well on a cable to a known location and used as a marker to locate depth of fluid.

23.

Is the printed sheet (now Plaintiffs' Exhibit 7)

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

herein a publication published and distributed by or on behalf of the defendant?

Answer: Yes.

24.

Does Exhibit 7 correctly describe and illustrate those methods and apparatus, or any of them, admitted in Paragraph IX of the answer herein to have been employed by defendant for

(a) measuring the location of obstructions in wells;

Answer: Yes.

(b) determining in oil wells the fluid density;

Answer: No.

(c) determining in oil wells the fluid pressure; and

Answer: Yes.

(d) determining the production capacity of oil wells?

Answer: Yes. See answer to Interrogatory No. 2.

25.

If the answer to Interrogatory 24 is "no", with respect to any of the items (a), (b), (c) or (d), state in what manner the apparatus and methods used by defendant with respect to said "no" answer differs from the respective methods and apparatus described and illustrated therefor in Exhibit 7.

Answer: See answer to Interrogatory No. 3.

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

26.

If the answer to Interrogatory 24 is "no" with respect to any of the items (a), (b), (c) or (d), furnish to plantiffs detailed description and drawings illustrating the method and apparatus employed to perform any of the items to which a "no" answer is made to Interrogatory 24.

Answer: See answer to Interrogatory No. 4.

27.

Are the record sheets, (now Plaintiffs' Exhibit 8-A, 8-B, 8-C, 8-D, and 9) copies of actual records made by the defendant?

Answer: Yes.

28.

Each of the sheets of the records, Plaintiffs' Exhibits 8-A, 8-B, 8-C, 8-D, and 9, are signed "J. H. Show". State whether or not J. H. Show was on or about November 19-25, 1940 employed by defendant and engaged in making fluid level measurements, sub-surface pressure determinations, bottom hole pressure determinations, production capacity determinations, well potential determinations and productivity index determinations of the character admitted in Paragraphs IX and XI of defendant's answer herein.

Answer: Yes.

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

29.

Are the methods of

(a) determining sub-surface pressures;

(b) determining bottom hole pressures;

(c) determining production capacities;

(d) determining well potenials;

(e) determining the productivity index of oil wells; or any of them, admitted to have been performed by defendant in Paragraph IX and XI of the defendant's answer herein, accurately described in Pages 5 through 9 of the folder, plaintiffs' Exhibit 6?

Answer: Yes. See also Plaintiffs' Exhibit 11-C.

30.

If the answer to Interrogatory 29 is "no" with respect to any of the items (a), (b), (c), (d) or (e), furnish to the plaintiffs detailed descriptions and drawings illustrating the methods and apparatus employed to perform any of the items to which a "no" answer is made to Interrogatory 29.

Answer: Requires no answer.

31.

In determining the density of the standing column of fluid in a well, state which of the following steps is used by the defendant and which of said steps is not used by the defendant:

(a) measuring the fluid level of the column under one condition of gas pressure in the casing;

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

(b) changing the pressure of gas within the casing to move the surface of the fluid column to a different level;

(c) measuring the new level of the fluid column; and

(d) dividing the change in pressure on the fluid surface required to achieve the new level by the difference in height between the two levels.

Answer: Defendant does not know what steps were employed where density has been determined by employees of defendant. See answer to Interrogatories Nos. 3 and 4.

32.

If the answer to any subdivision of Interrogatory 31 is in the negative, describe the differences between the step or steps employed by defendant for determining the density of the standing column of fluid in a well from that set forth in the subdivision of Interrogatory 31 negatively answered.

Answer: Defendant does not know. See answer to Interrogatory No. 31.

33.

In determining the density of fluid in a well having a casing and a pump suspended therein on tubing, and without requiring the removal of pump parts, which of the following steps is used by the defendant and which of said steps is not used by defendant:

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

(a) determining the fluid level in the annular space between the pump tubing and the casing under one condition of gas pressure;

(b) changing the pressure of gas within the well to move the fluid surface to a new level;

(c) measuring the new level; and

(d) dividing the change in pressure on the fluid surface required to achieve the new level by the difference between the two levels?

Answer: Defendant does not know. See answer to Interrogatory No. 31.

34.

If the answer to any subdivision of Interrogatory 33 is in the negative, then describe the difference between the step or steps employed by defendant for determining the density of the fluid in a well from that set forth in the subdivision of Interrogatory 33 which is negatively answered.

Answer: Defendant does not know. See answer to Interrogatory No. 31.

35.

In the defendant's method of determining the density of the standing column of fluid in a well having a casing and a pump suspended therein, state which of the following steps is used by the defendant and state which of the following steps are not used by the defendant:

(a) measuring the level of the standing column

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

of fluid in the well while the pump therein is operated at a given rate of production and under a known condition of gas pressure on the surface of the fluid column;

(b) changing the gas pressure on the fluid column;

(c) continuing the operation of the pump at the same production rate until the level of the standing column becomes stable at a new location;

(d) measuring the new level; and

(e) comparing the difference in the two pressures exerted on the fluid surface at the two levels with the difference in height of the two levels?

Answer: Defendant does not know. See answer to Interrogatory No. 31.

36.

If the answer to any subdivision of Interrogatory 35 is in the negative, describe in detail the difference between the step or steps employed by defendant for determining the density of the standing column of fluid in a well from that set forth in the subdivision of Interrogatory 35 negatively answered.

Answer: Defendant does not know. See answer to Interrogatory No. 31.

37.

In the defendant's method of determining the density of the standing column of fluid in a well

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

having a casing and a pump suspended therein, state which of the following steps is used by the defendant and state which of the following steps are not used by the defendant:

(a) measuring the stable level of the surface of the standing column of fluid under one condition of pressure of gas released by the well;

(b) measuring the pressure on the fluid surface under said one condition of gas pressure;

(c) regulating the flow of gas from the well to increase the pressure of said gas to a different value to depress the surface of said standing column to a new stable level;

(d) measuring the new level;

(e) measuring the pressure on the fluid surface at the new level; and

(f) comparing the difference in the pressure exerted upon the fluid surface under the two conditions of gas pressure with the difference in height of the levels of the fluid surface under the two pressure conditions.

Answer: Defendant does not know. See answer to Interrogatory No. 31.

38.

If the answer to any subdivision of Interrogatory 37 is in the negative, describe in detail the difference between the step or steps employed by defendant for determining the density of the standing column of fluid in a well from that set forth in

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

the subdivision of Interrogatory 37 negatively answered.

Answer: Defendant does not know. See answer to Interrogatory No. 31.

39.

In the defendant's method of determining the density of a standing column of fluid in a well having a casing and a pump suspended therein upon pump tubing and without requiring the removal of pump parts, state which of the following steps is used by the defendant and state which of the following steps is not used by the defendant:

(a) operating the pump under one stable condition of gas pressure in the casing until the fluid level becomes stable;

(b) measuring the distance between the casing head and the surface of the fluid under this stable condition;

(c) altering the casing pressure to a new condition;

(d) operating the pump at the same rate of production under the new condition of gas pressure to again stabilize the fluid level;

(e) measuring the distance between the casing head and the new level of the fluid surface under said new stable condition; and

(f) measuring the casinghead pressures under the two stable conditions.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

Answer: Defendant does not know. See Answer to Interrogatory No. 31.

40.

If the answer to any subdivision of Interrogatory 39 is in the negative, describe in detail the differences between the step or steps employed by the defendant for determining the density of the standing column of fluid in an oil well from that set forth in the subdivision of Interrogatory 39 negatively answered.

Answer: Defendant does not know. See answer to Interrogatory No. 31.

41.

In the defendant's method of determining the pressure exerted in the standing column of fluid in a well at some selected level below the normal surface of the column and without requiring the removal of any of the pump parts, state which of the following steps is used by the defendant and state which of the following steps are not used by the defendant:

(a) measuring the actual stable level of the fluid column under one known condition of gas pressure in the casing;

Answer: Yes.

(b) determining the pressure on the fluid surface at that level;

Answer: No.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

(c) changing the pressure of gas in the well to move the surface of said column to a new actual stable level;

Answer: Yes.

(d) measuring the new level of the fluid surface;

Answer: Yes.

(e) determining the pressure on the fluid surface at the new level;

Answer: No.

(f) determining the density of the fluid by dividing the change in pressure on the fluid surface required to achieve the new level by the difference in height of the two levels; and

Answer: No.

(g) computing the unknown pressure at the desired level by adding to the pressure on the fluid surface at either of the levels the effect in pressure of the column of fluid of the density so determined between the selected actual level and the desired level.

Answer: No.

42.

If the answer to any subdivision of Interrogatory 41 is in the negative, describe in detail the differences between the step or steps employed by the defendant for determining the pressure exerted in the standing column of fluid in a well from that set forth in the subdivision of Interrogatory 41 negatively answered.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

Answer: The method employed by the defendant for determining pressure exerted in the standing column of fluid in a well is described correctly and fully in the manual, Exhibit 11-C, and in Plaintiffs' Exhibit No. 6. The manual, Exhibit 11-C, describes several methods, but distinguishes those used by defendant from other methods.

43.

In the defendant's method of determining the pressure exerted in the standing column of fluid at some selected level below the normal surface of the column and while the pump is operating to remove fluid from the well, state which of the following steps is used by the defendant and state which of the following steps are not used by the defendant:

(a) measuring the actual stable level of the fluid under one known condition of gas pressure in the well by sonic sounding method;

Answer: Yes.

(b) determining the pressure on the fluid surface at that level;

Answer: No.

(c) changing the pressure of the gas in the well to move the surface of the column to a new actual level;

Answer: Yes.

(d) continuing to operate the pump at the same production rate as for the first condition of gas pres-

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

sure in the well until the fluid level again becomes stable;

Answer: Yes.

(e) measuring the new stable level and determining the pressure upon the fluid surface at this new level;

Answer: No.

(f) determining the pressure exerted per unit of height of the fluid column by dividing the change in gas pressure on the fluid surface required to effect the change in the fluid level by the difference in height of the two levels; and

Answer: No.

(g) computing the unknown pressure at the selected level by adding to the gas pressure upon the fluid surface at one of the actual levels the effect in pressure of the fluid column between the actual level and the selected level.

Answer: No.

44.

If the answer to any subdivision of Interrogatory 43 is in the negative, describe in detail the difference between the step or steps employed by the defendant for determining the pressure exerted in the standing column of fluid at some selected level in a well from that set forth in the subdivision of Interrogatory 43 negatively answered.

Answer: See answer to Interrogatory No. 42.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

45.

In the defendant's method of determining the potential production capacity of a well having a casing and a pump suspended therein, state which of the following steps is used by the defendant and state which of the steps are not used by the defendant:

(a) measuring the level of the standing column of fluid in the well at one known rate of production and under one known condition of gas pressure in the well;

Answer: No.

(b) determining the pressure on the surface of the fluid column at that level;

Answer: No.

(c) changing the gas pressure in the well to move the surface of the fluid column to a new level;

Answer: Yes.

(d) measuring the level of the fluid surface under the new gas pressure condition;

Answer: Yes.

(e) determining the pressure on the fluid surface at the new level;

Answer: No.

(f) Dividing the change in pressure on the fluid surface by the difference in height between the two levels to determine the density of the fluid in the column at that rate of production;

Answer: No.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

(g) determining the pressure at some predetermined desired point below the normal fluid surface for that rate of production by adding to the pressure at the fluid surface for either of the measured levels the effect in pressure of the column of fluid between that level and the predetermined desired point;

Answer: No.

(h) changing the rate of production by the pump and repeating the fluid level change and gas pressure determinations to determine the density of the fluid in the column and the pressure of the fluid at some predetermined desired point for the new rate of production;

Answer: No.

(i) dividing the difference in the two production rates by the difference in the corresponding fluid pressures at the desired point; and

Answer: Yes.

(j) using the ratio thus found to determine the maximum rate at which the well is capable of being produced.

Answer: Yes.

46.

If the answer to any subdivision of Interrogatory 45 is in the negative, describe in detail the difference between the step or steps empoyed by the defendant for determining the potential production capacity of a well having a casting and a pump suspended therein from that set forth in the subdivision of Interrogatory 45 negatively answered.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

Answer: The steps employed by defendant for determining the potential production capacity of a well having a casing and pump suspended therein, is described correctly and fully in Plaintiffs' Exhibit 11-C.

47.

In the defendant's method of determining the pressure exerted by the well fluid at any point below the normal surface thereof, state which of the following steps is used by the defendant and state which of the following steps are not used by the defendant:

(a) determining the location of the fluid surface under one condition of pressure of gas on the surface;

Answer: No.

(b) determining said gas pressure under said one condition;

Answer: No.

(c) changing the gas pressure to move the fluid surface to a new stable level;

Answer: Yes.

(d) determining the new gas pressure on the fluid surface;

Answer: No.

(e) determining the location of the new surface level; and

Answer: Yes.

(f) comparing the difference in the gas pressures

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

with the corresponding change in height of the surface level to determine the relation between them.

Answer: No.

48.

If the answer to any subdivision of Interrogatory 47 is in the negative, describe in detail the difference between the step or steps employed by the defendant for determining the pressure exerted by the well fluid at any point below the normal surface thereof from that set forth in the subdivision of Interrogatory 47 negatively answered.

Answer: See answer to Interrogatory No. 42.

49.

In the defendant's method of determining the pressure exerted by the well fluid at any point below the surface thereof while a mechanical pump is operating in that well, state which of the following steps is used by the defendant and state which of the following steps are not used by the defendant:

(a) determining the stable location of the fluid surface under one condition of gas pressure in the casing in the well;

Answer: Yes.

(b) determining the gas pressure on the fluid surface at that level;

Answer: No.

(c) changing the pressure of gas in the casing to move the fluid surface to a new stable level;

Answer: Yes.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

(d) determining the new location of the fluid surface;

Answer: Yes.

(e) determining the gas pressure on the surface at the new level; and

Answer: No.

(f) comparing the difference between the pressures on the surface with the corresponding change in height of the fluid surface to determine the relation between changes in pressure on the fluid surface and the corresponding changes in the location of the fluid surface.

Answer: No.

50.

If the answer to any subdivision of Interrogatory 49 is in the negative, describe in detail the difference between the step or steps employed by the defendant for determining the pressure exerted by the well fluid from that set forth in the subdivision of Interrogatory 49 negatively answered.

Answer: See answer to Interrogatory No. 42.

51.

In the defendant's method of determining the potential production capacity of a well having a casing and a pump suspended therein, state which of the following steps is used by the defendant and state which of the following steps are not used by the defendant:

(a) determining the pressure exerted by the well

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

fluid at some selected point below the normal surface thereof under one known rate of production by

(1) determining the location of the fluid surface under one condition of gas pressure on the surface.

(2) determining the gas pressure on the fluid surface under said one condition;

(3) changing the gas pressure to move the fluid surface to a new stable level under the same production rate;

(4) determining the new gas pressure on the fluid surface;

(5) determining the location of the new surface level;

(6) comparing the difference in said gas pressures with the corresponding change in height of the new surface level to ascertain the pressure exerted at said selected point under said one rate of production;

Answer: No. Defendant employs the steps listed in a-3 and a-5, and does not employ the steps listed in a-1, a-2, a-4 and a-6.

(b) changing the rate of production from said well;

Answer: Yes.

(c) repeating the steps of determining the location of the fluid surface at two stable levels and the gas pressures on said surface to maintain said levels under the new production rate to ascertain the pressure exerted at the same selected point; and

Answer: No.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

(d) comparing the difference in production rates with the corresponding difference in pressures at said selected point to determine their relation from which the maximum rate of production from the well may be determined.

Answer: Yes.

52.

If the answer to any subdivision of Interrogatory 51 is in the negative, describe in detail the difference between the step or steps employed by the defendant for determining the potential production capacity of a well from that set forth in the subdivision of Interrogator 51 negatively answered.

Answer: See answer to Interrogatory No. 46.

53.

In the defendant's method of determining the density of the standing column of fluid in a well, state which of the following steps is used by the defendant and state which of the following steps are not used by the defendant:

(a) measuring the level of the fluid column under one condition of gas pressure;

(b) measuring the gas pressure at the casing head of the well;

(c) changing the gas pressure at the casing head of the well to move the surface of the fluid column to a new level;

(d) measuring the new level; and

(e) comparing the change in gas pressure at the

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

casing head with the difference in height between the two levels.

Answer: Defendant does not know. See answer to Interrogatory No. 31.

54.

If the answer to any subdivision of Interrogatory 53 is in the negative, describe in detail the difference between the step or steps employed by the defendant for determining the density of the standing column of fluid in a well from that set forth in the subdivision of Interrogatory 53 negatively answered.

Answer: Defendant does not know. See answer to Interrogatory No. 31.

55.

In the defendant's method of determining the pressure exerted in the standing column of fluid in the well at some selected level below the normal surface of the column and without requiring the removal of the pump parts, state which of the following steps are used by the defendant and state which of the following steps are not used by the defendant:

(a) measuring the actual level of the fluid surface of the fluid column under one known condition of gas pressure at the casing head;

Answer: In answering Interrogatory No. 55, it should be noted that steps (a), (b) and (d) do not constitute a complete method of determining the

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

pressure exerted in the standing column of fluid in the well at some selected level, as called for in the question.

Answer: (a) Yes.

(b) changing the pressure of the gas at the casing head to move the surface of the fluid column to a new actual level;

Answer: (b) Yes.

(c) measuring the new level of the fluid surface; and

Answer: (c) Yes.

(d) comparing the difference in height of the two actual levels with the casing head pressures of gas under which the two levels were measured to determine the casing head pressure which would be required to move the surface of the fluid column to the selected level.

Answer: Yes.

56.

If the answer to Interrogatory 55 is in the affirmative, does defendant make any compensation for the difference between the casinghead pressure and the effect in pressure of the column of gas in the well?

Answer: No. Defendant does not make any compensation for the difference between the casinghead pressure and the effect in pressure of the column of gas in the well. Defendant does compensate for the difference between the effect in pressure of the theoretical column of gas in the well at the

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

theoretical casinghead pressure which would be required to move the surface of the liquid column to the selected level, as recited in step (d) of Interrogatory No. 55.

57.

If the answer to Interrogatory 56 is in the affirmative, state how such compensation is made.

Answer: The compensation referred to in the answer to Interrogatory No. 56 is obtained by taking the theoretical casinghead gas pressure and the theoretical height of the column of gas and applying Dice's formula or the equivalent. (For Dice's formula, see page 151 of the publication, Defendant's Exhibit K-3, "Sub-Surface Pressures in Oil Wells and their Field of Application", by D. G. Hawthorne published in 1933, cited in the Answer herein).

58.

If the answer to Interrogatory 55 is in the negative, then describe in detail the differences between the method which is employed by the defendant for determining the pressure exerted in the standing column of fluid in the well at some selected level below the normal surface of the column and without requiring the removal of the pump parts and the method steps set forth in Interrogatory 55.

Answer: See answers to Interrogatories 56 and 57. See also, Exhibit 11-C, which correctly and fully describes the method employed by defendant for de-

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

termining the pressure exerted in the standing column of fluid in a well at some selected level.

59.

In the defendant's method of determining the potential capacity of an oil well or the productivity index of an oil well, state which of the following steps are used by the defendant and state which of the following are not used by the defendant:

(a) determining the pressure exerted by the well fluid at the pump under one rate of production of oil from the well by the pump by

(1) measuring the fluid level under one condition of gas pressure in the well;

(2) measuring that one gas pressure in the well;

(3) changing the gas pressure in the well to move the fluid surface to a new level;

(4) measuring the new level of the fluid surface;

(5) measuring the new gas pressure in the well;

(6) comparing the differences in height of the two fluid levels with the difference in the two gas pressures to thereby determine the pressure at the pump;

Answer: No. Defendant determines the gas pressure at the casing head but does not determine the gas pressure in the well. Defendant does not employ the steps enumerated as 2, 5 and 6 of item (a) of Interrogatory No. 59.

(b) changing the rate of production of oil from the well;

Answer: Yes.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

(c) repeating the steps of determining the location of the fluid surface at two levels and the gas pressures in the well required to maintain the said levels under the new production rate and comparing the difference in levels of the fluid surface and the difference in pressures required to maintain them to determine the pressure at the pump under the new production rate; and

Answer: No; same as answer to 59 (a).

(d) comparing the two pressures at the pump with the two production rates to determine the productivity index or potential production capacity of the well.

Answer: Yes.

60.

If the answer to any subdivision of Interrogatory 59 is in the negative, describe in detail the difference between the step or steps employed by the defendant for determining the potential capacity of an oil well or the productivity index of an oil well from that set forth in the subdivision of Interrogatory 59 negatively answered.

Answer: Defendant's method for determining the potential capacity of a well or the productivity index is correctly and fully described in Exhibit 11-C.

61.

Is the chart, Fig. 1 on Page 6 of the folder, Plaintiff's Exhibit 6, a correct representation of the manner in which defendant utilizes fluid level mea-

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

surements and gas pressure measurements to determine the fluid pressure at the pump under two different rates of production of fluid from the well?

Answer: Yes.

62.

If the answer to Interrogatory 61 is in the negative, then furnish a chart used by defendant which does correctly set forth the information recited in the Interrogatory 61 and describe in detail the difrences between the chart furnished and the chart referred to in Interrogatory 61.

Answer: Requires no answer.

63.

In the defendant's method of determining the unknown location of an obstruction in a well having a string of tubing therein constructed of a plurality of lengths of tubing connected to each other by couplings, state which of the following steps are used by the defendant and state which of the following steps are not used by the defendant:

(a) creating a pressure impulse in the annular space between the tubing and the casing of the well;

Answer: No.

(b) registering the echoes from the tubing collars and from the obstruction of unknown location; and

Answer: Yes.

(c) counting the tubing collar echoes occurring between the creation of the pressure impulse and the

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

echo from the obstruction of unknown location to determine the location of the obstruction of unknown location.

Answer: No.

64.

If the answer to any subdivision of Interrogatory 63 is in the negative, describe in detail the difference between the step or steps employed by the defendant for determining the unknown location of an obstruction in a well having a string of tubing therein from that set forth in the subdivision of Interrogatory 63 negatively answered.

Answer: The method employed by defendant for determining the unknown location of an obstruction (fluid level) in a well is correctly and fully described in Plaintiffs' Exhibit 6 and in Exhibit 11-C. Defendant does not employ apparatus for creatng a pressure impulse but employs apparatus for making a sound.

65.

Attached hereto (Exhibit 10-B) is a copy of nine strips of record tape, each bearing the name "Echometer Service", "Cities Service Oil"; state whether or not Exhibit 10-B is a true copy of the record charts made by the defendant at the Cities Service Oil Company Lease Ray B Wall No. 2, on the dates and times indicated on Exhibit 10-B.

Answer: Yes, but the date is subsequent to the filing of the Complaint herein.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

66.

On the record charts shown in Exhibit 10-B are notations "10", "20", "30", "40", "34.8", "40.9", "49.35", and similar markings beside the peaks of the record chart; state whether or not it is ever the practice of the defendant or its employees to place such markings on the record charts produced by the defendant.

Answer: Yes.

67.

If the answer to Interrogatory 66 is in the affirmative, state what those notations "10", "20", "30", etc. mean.

Answer: The numerals 10, 20, 30, etc. referred to are counts by the operator of the number of reflections from collars of tubing.

68.

Attached hereto (Exhibit 10-C) is a copy of six strips of record tape, each bearing the name "Echometer Service", "Phillips Petro. Co."; state whether or not Exhibit 10-C is a true copy of the record charts made by the defendant at the Phillips Petroleum Co. Lease Kraft, Well No. 3, on the dates and times indicated on Exhibit 10-C.

Answer: Yes.

69.

On the record charts shown in Exhibit 10-C are notations "41^0", "51^4", "37^2", "36^8", "31^2" and

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

"31" beside the peaks of the record chart; state whether or not it is ever the practice of the defendant or its employees to place such markings on the record charts produced by the defendant.

Answer: Yes.

70.

If the answer to Interrogatory 69 is in the affirmative, state what those notations "41^0", "41^4", etc. mean.

Answer: Same as answer to Interrogatory No. 67.

71.

In the defendant's method of determining the unknown location of an obstruction in a well having a string of tubing therein, state which of the following steps are used by the defendant and state which of the following steps are not used by the defendant:

(a) creating an acoustical impulse in the annular space between the tubing and the well casing to produce echoes from portions of the tubing string distinguishable from each other and from the echo from the unknown obstruction;

Answer: No. Defendant creates an acoustical wave but not an impulse in the annular space. The acoustical wave does not produce distinguishable echoes as stated in Interrogatory 71 (a).

(b) observing the lapse of time between the arrival at a predetermined point of the echoes from successive portions of the tubing string to thereby

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

determine the velocity of the pressure wave through the particular well under measurement; and

Answer: No.

(c) measuring the lapse of time between the creating of the pressure impulse and the arrival at some predetermined point of the echo from the unknown obstruction.

Answer: No.

72.

If the answer to any subdivision of Interrogatory 71 is in the negative, describe the difference between the step or steps employed by the defendant for determining the unknown location of an obstruction in a well having a string of tubing therein from that set forth in the subdivision of Interrogatory 71 negatively answered.

Answer: The defendant's method referred to is correctly and fully described in Plaintiffs' Exhibit 6, and Exhibit 11-C.

73.

In the defendant's method of determining the unknown location of an obstruction in a well having a string of tubing therein, state which of the following steps are used by the defendant and state which of the following steps are not used by the defendant:

(a) creating an acoustical impulse in the annular space between the tubing and the well casing of such magnitude as compared with the depth of the well and the resistance to pressure wave transmission therethrough as will produce echoes from por-

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

tions of the tubing string distinguishable from each other and from the echo from the unknown obstruction;

Answer: No.

(b) observing the lapse of time between the arrival at a predetermined point of the echo from successive portions of the tubing string to thereby determine the velocity of the pressure wave through the particular well under measurement; and

Answer: No.

(c) measuring the lapse of time between the creating of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

Answer: No.

74.

If the answer to any subdivision of Interrogatory 73 is in the negative, describe in detail the difference between the step or steps employed by the defendant for determining the unknown location of an obstruction in a well having a string of tubing therein from that set forth in the subdivision of Interrogatory 73 negatively answered.

Answer: See answer to Interrogatory No. 72.

75.

In the defendant's method of determining the unknown location of an obstruction in a well having a casing with tubing therein restricting the volume of the annular space within the casing and

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

having another obstruction therein at a know location above the unknown obstruction, state which of the following steps are used by the defendant and state which of the following steps are not used by the defendant:

(a) creating in the annular space an acoustical impulse to produce echoes from different obstructions distinguishable from each other;

Answer: No.

(b) observing the lapse of time between the creation of the impulse and the arrival at a predetermined point of the echo from the unknown obstruction; and

Answer: No.

(c) comparing with said time lapse the time lapse between the creation of the impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

Answer: No.

76.

If the answer to any subdivision of Interrogatory 75 is in the negative, describe the difference between the step or steps employed by the defendant for determining the unknown location of an obstruction in a well from that set forth in the subdivision of Interrogatory 75 negatively answered.

Answer: See answer to Interrogatory No. 72.

77.

In the defendant's method of determining the unknown location of an obstruction in a well hav-

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

ing a casing with tubing therein restricting the volume of the annular space within the casing and having another obstruction therein at a known location above the unknown obstruction, state which of the following steps are used by the defendant and state which of the following steps are not used by the defendant:

(a) creating in the annular space an acoustical impulse of such magnitude as compared with the depth of the well and the resistance to pressure wave transmission therethrough as will produce echoes from different obstructions distinguishable from each other;

Answer: No.

(b) observing the lapse of time between the creation of the impulse and the arrival at a predetermined point of the echo from the unknown obstruction; and

Answer: No.

(c) measuring the lapse of time between the creation of the impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

Answer: No.

78.

If the answer to any subdivision of Interrogatory 77 is in the negative, describe the difference between the step or steps employed by the defendant for determining the unknown location of an obstruction in a well from that set forth in the sub-

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

division of Interrogatory 77 negatively answered.

Answer: See answer to Interrogatory No. 72.

79.

In the defendant's method of determining the unknown location of an obstruction in a well, state which of the following steps are used by the defendant and state which of the following steps are not used by the defendant:

(a) placing another obstruction in the well at a known depth in the well;

Answer: Yes, occasionally. See answer to Interrogatory No. 22.

(b) creating a pressure impulse in the well;

Answer: No.

(c) observing the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo thereof from the obstruction of known location; and

Answer: No.

(d) measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

Answer: No.

80.

If the answer to any subdivision of Interrogatory 79 is in the negative, describe in detail the difference between the step or steps employed by the defendant for determining the unknown location of an obstruction in a well from that set forth in

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

the subdivision of Interrogatory 79 negatively answered.

Answer: See answer to Interrogatory No. 72.

81.

In the defendant's method of determining the unknown location of an obstruction in a well having a casing with tubing therein restricting the volume of the annular space within the casing and having an approximately known depth and a known pressure of gas within said space from which the approximate magnitude of acoustical impulse required to traverse the restricted space and produce echoes from the several obstructions in the well may be estimated, state which of the following steps are used by the defendant and which of the following steps are not used by the defendant:

(a) introducing into said space between the casing and the tubing a series of acoustical impulses, each of different magnitude approximating the estimated magnitude to produce from each impulse echoes from the different obstructions in the well;

Answer: No.

(b) observing the echoes that are produced by each impulse to select the one that produces distinguishable echoes from each of the obstructions in the well; and

Answer: No.

(c) recording the echoes of an impulse of the selected magnitude in the relative times and order

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

in which they are received at the ground surface.

Answer: No.

In answer to this interrogatory, defendant states further that the introductory portion of Interrogatory No. 81 does not define the objects of defendant's method. Defendant does not care to know the "approximately known depth and known pressure of gas" within the annular space, and makes no estimate of the magnitude of an impulse which would be required to traverse the restricted space.

82.

If the answer to any subdivision of Interrogatory 81 is in the negative, describe in detail the difference between the step or steps employed by the defendant for determining the unknown location of an obstruction in a well from that set forth in the subdivision of Interrogatory 81 negatively answered.

Answer: See answer to Interrogatory No. 72.

83.

In the defendant's method of determining the unknown location of an obstruction in a well having a string of pipe therein consisting of sections of known mean length connected by couplings, state which of the following steps are used by defendant:

(a) creating an impulse in the well adapted to produce an echo from each of a plurality of suc-

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

cessive couplings and from the obstruction of unknown location;

Answer: No.

(b) sequentially registering the impulse and such echoes in spaced relation to each other proportional to the actual relative spacing of the coupling and the unknown obstruction; and

Answer: No.

(c) computing the distance to the unknown obstruction from said known mean length between successive couplings and the number of registered coupling echoes.

Answer: Yes.

84.

If the answer to any subdivision of Interrogatory 83 is in the negative, describe in detail the difference between the step or steps employed by the defendant for determining the unknown location of an obstruction in a well having a string of pipe therein from that set forth in the subdivision of Interrogatory 83 negatively answered.

Answer: See answer to Interrogatory No. 72.

85.

In the defendant's method of determining the distance to an unknown location of an obstruction in a well having a casing with tubing therein restricting the volume of the annular space within the casing and having another obstruction therein at a known location, state which of the following steps are not used by defendant and which of the following steps are used by defendant:

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

(a) creating at some known point within the casing an impulse to produce echoes from said obstructions distinguishable from each other;

Answer: No.

(b) sequentially registering the impulse and the echoes from said obstructions in spaced relation to each other; and

Answer: No.

(c) determining the distance to the unknown obstruction from said known point of impulse by comparing the elapsed time between the registrations of the impulse and the echo from the known obstruction with the elapsed time between the registrations of the impulse and the echo from the unknown obstruction.

Answer: No. In answer to item (c) of Interrogatory No. 85, defendant states that it computes the distance to the obstruction (fluid level) by multiplying the number of joints of tubing by the length of each joint, obtaining the answer directly in feet, instead of computing the elapsed time.

86.

If the answer to any subdivision of Interrogatory 85 is in the negative, describe in detail the difference between the step or steps employed by the defendant for determining the distance to an unknown location of an obstruction in a well from that set forth in the subdivision of Interrogatory 85 negatively answered.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

Answer: See answer to Interrogatory No. 72.

87.

In the defendant's method of determining the location of an obstruction in a well, state which of the following pieces of apparatus are used by the defendant and state which pieces of said apparatus are not used by the defendant:

(a) means communicating with the well for creating a pressure impulse in the well;

Answer: No.

(b) echo receiving means including a pressure responsive device exposed to the well for receiving pressure impulses from the well and for measuring the lapse of time between the creation of the impulse and the arrival at the receiving means of the echo from the obstruction; and

Answer: No.

(c) means associated with the pressure responsive device for tuning the receiving means to the frequency of echoes from the tubing collars of tubing sections of the well to clearly distinguish the echoes from the couplings from each other.

Answer: No.

88.

If the answer to any subdivision of Interrogatory 87 is in the negative, describe in detail the difference between the apparatus employed by the defendant for determining the location of an obstruction in a well from that set forth in the subdivision of Interrogatory 87 negatively answered.

Answer: See answer to Interrogatory No. 72.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

89.

In the defendant's method of determining the location of an obstruction in a well, state which of the following pieces of apparatus are used by the defendant and state which of said pieces of apparatus are not used by the defendant;

(a) means communicating with the well for creating a pressure impulse in the well;

Answer: No.

(b) a pressure responsive device for receiving pressure impulses from the well;

Answer: No.

(c) means coupling said pressure responsive device to the well to expose the device to pressure variations existing in the well and having a length approximately a multiple of the length of a tubing section in the well to tune the device to the frequency of the echoes from the impulse received from the couplings of the tubing string; and

Answer: No.

(d) means associated with the device for recording the echoes from the tubing couplings and from the obstruction to permit counting the coupling echoes between the creation of the impulse and the echo from the unknown obstruction to determine its location.

Answer: No.

90.

If the answer to any subdivision of Interrogatory 89 is in the negative, describe in detail the differ-

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

ence between the apparatus employed by the defendant for determining the location of an obstruction in a well from that set forth in the subdivision of Interrogatory 89 negatively answered.

Answer: See answer to Interrogatory No. 72.

91.

In the defendant's method of locating an obstruction in a well, state which of the following pieces of apparatus are used by the defendant and which of said pieces of apparatus are not used by the defendant:

(a) means communicating with the well for creating a pressure impulse in the well to produce echoes of the impulse from the tubing couplings and other obstructions in the well;

Answer: No.

(b) echo receiving and registering means coupled to the well to expose the receiving and registering means to pressure variations produced in the well by echoes from the obstructions; and

Answer: No.

(c) means associated with the receiving and registering means to accent the registration of tubing coupling echoes.

Answer: No.

92.

If the answer to any subdivision of Interrogatory 91 is in the negative, describe in detail the difference between the apparatus employed by the de-

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

fendant for determining the location of obstructions in wells from that set forth in the subdivision of Interrogatory 91 negatively answered.

Answer: See answer to Interrogatory No. 72.

93.

In the defendant's method for determining the unknown location of an obstruction in a well, state which of the following pieces of apparatus are used by the defendant and which of the following pieces of apparatus are not used by the defendant:

(a) means communicating with the well for creating a pressure impulse in the well to produce echoes of the impulse from tubing couplings and other obstructions in the well;

Answer: No.

(b) pressure responsive echo receiving and registering means coupled to the well to expose the receiving and registering means to pressure variations in the well produced by echoes from the obstructions; and

Answer: No.

(c) an interference eliminating means associated with the receiving and registering means for limiting the response of the receiving and registering means to the registration of echoes from actual obstructions in the well.

Answer: No.

94.

If the answer to any subdivision of Interrogatory 93 is in the negative, describe in detail the differ-

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

ence between the apparatus employed by the defendant for determining the unknown location of an obstruction in a well from that set forth in the subdivision of Interrogatory 93 negatively answered.

Answer: See answer to Interrogatory No. 72.

95.

In the defendant's method of determining the unknown location of an obstruction in a well, state which of the following pieces of apparatus are employed by the defendant and which of said pieces of apparatus are not employed by the defendant:

(a) means communicating with the well for creating a pressure impulse in the well to produce echoes of said impulse from the tubing couplings and other obstructions in the well;

Answer: No.

(b) pressure responsive echo receiving and registering means coupled to the well to expose the receiving and registering means to the pressure variations produced in the well by echoes from the obstructions; and

Answer: No.

(c) resonance means associated with said receiving and registering means to produce therein a natural acoustical period of oscillation so related to the frequency of the echoes from the tubing couplings as to accent the registration of the tubing coupling echoes.

Answer: No.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

96.

If the answer to any subdivision of Interrogatory 95 is in the negative, describe in detail the difference between the apparatus employed by the defendant for determining the unknown location of an obstruction in a well from that set forth in the subdivision of Interrogatory 95 negatively answered.

Answer: See answer to Interrogatory No. 72.

97.

In the defendant's method of determining the unknown location of an obstruction in a well, state which of the following pieces of apparatus are used by the defendant and which of said pieces of apparatus are not used by the defendant:

(a) means communicating with the well for creating therein a pressure impulse to produce echoes of the impulse from the tubing couplings and other obstructions in the well;

Answer: No.

(b) echo receiving and registering means including a pressure responsive device and pipe means coupling the pressure responsive device to the well to expose the device to pressure variations in the well; and

Answer: No.

(c) means for adjusting the effective length of the pipe means to produce a natural acoustical period of oscillation of the pressure responsive device so related to the frequency of the echoes from

tubing couplings as to accent the registration of said echoes.

Answer: No.

98.

If the answer to any subdivision of Interrogatory 97 is in the negative, describe in detail the difference between the apparatus employed by the defendant for determining the unknown location of an obstruction in a well from that set forth in the subdivision of Interrogatory 97 negatively answered.

Answer: See answer to Interrogatory No. 72.

99.

In the defendant's method of determining the unknown location of an obstruction in a well, state which of the following pieces of apparatus are employed by the defendant and which of said pieces of apparatus are not employed by defendant:

(a) means communicating with the well for creating therein a pressure impulse to produce echoes of said impulse from the tubing coupling and other obstructions in the well;

Answer: No.

(b) pressure responsive echo receiving and registering means having a natural frequency of oscillation so related to the frequency of echoes from the tubing couplings as to accent the registration of said echoes; and

Answer: No.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

(c) means interconnecting the receiving and registering means to the well to expose the receiving and registerming means to pressure variations in the well.

Answer: No.

100.

If the answer to any subdivision of Interrogatory 99 is in the negative, describe in detail the difference between the apparatus employed by the defendant for determining the unknown location of an obstruction in a well from that set forth in the subdivision of Interrogatory 99 negatively answered.

Answer: See answer to Interrogatory No. 72.

101.

State whether or not the defendant purchased that part of its business which includes methods and apparatus for determining the location of obstructions in wells, determining fluid density in oil wells, determining fluid pressure in oil wells and determining production capacity in oil wells, as admitted by defendant in Paragraph X of its answer herein, from International Geophysics, Inc. or J. J. Jakosky, or either of them, and if so, which one?

Answer: No. It is not correct to say that defendant purchased that part of its business which includes methods and apparatus for doing the things recited from International Geophysics, Inc. or J. J. Jakosky, or either of them. Defendant began de-

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

veloping sonid fluid level locating apparatus in February, 1938 and had built and tested its own apparatus by the end of July, 1938. At that time defendant had not conducted any negotiations with International Geophysics, Inc. or J. J. Jakosky, looking toward the purchase of any business, apparatus, patents or the like relating to this subject matter. Negotiations were opened about February, 1940 with International Geophysics, Inc. Defendant purchased by a contract made as of the 1st day of May, 1940, the entire "Echo-Meter" business of International Geophysics, Inc., together with equipment, patent rights, good will, etc.

Defendant did not purchase from International Geophysics, Inc. or J. J. Jakosky any apparatus for determining fluid density in oil wells, and defendant did not purchase from anyone methods for doing the things referred to in this interrogatory, the methods defendant uses having already become public property.

102.

State whether or not, at the time defendant acquired that part of its business pertaining to the methods and apparatus admitted to be used by the defendant in Paragraph IX of its answer, any investigation was made of the patent situation relating to said methods, and apparatus to determine whether or not said methods and apparatus would infringe any United States Letters Patent.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

Answer: No. An investigation of the patent situation relating to the methods and apparatus referred to was first made for defendant in January, 1939. Subsequently, knowledge of the art was kept current, but no new investigation was made at the time of the execution of the agreement with International Geophysics, Inc. in May, 1940 or during the negotiations leading up to the execution of that agreement. However, in May, 1940, defendant was familiar with those patents which had then issued to plaintiffs. (Patent No. 2,209,944 had not yet issued.)

103.

If the answer to Interrogatory 102 is "yes", state whether or not the defendant as a result of such investigation became aware of the existence of the United States Letters Patent in suit herein.

Answer: Requires no answer.

104.

State when the defendant first learned of each of the United States Letters Patent in suit herein.

Answer: Defendant obtained copies of each of the patents here in suit probably within a month after the issuance thereof.

105.

State how the defendant first received knowledge of the existence of each of the United States Letters Patent in suit herein.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

Answer: An employee of defendant reviews the Official Gazette of the U. S. Patent Office every week, and orders copies of patents which relate to defendant's business. Copies of the letters patent in suit were so noticed, ordered and received.

106.

State whether or not the defendant has ever received from the plaintiff or its representatives any notification, oral or written, charging defendant with infringing any of the Letters Patent in suit.

Answer: No. No written or formal notice of a charge of infringement was received from plaintiffs prior to the filing of the Complaint herein. Prior to the filing of the Complaint, plaintiffs endeavored to sell their fluid level locating business to defendant or reach a "friendly workable agreement" and during negotiations the patents here in suit were extolled, but plaintiffs professed ignorance of the details of what defendant was doing and defendant denies that any notice, either oral or written, was ever given defendant.

107.

On July 6, 1939 a formal notice of infringement of United States Letters Patent Nos. 2,156,519 and 2,161,733 was sent by Plaintiffs to International Geophysics, Inc.; state whether or not the defendant has ever received any knowledge of said notice of infringement and when said knowledge was acquired by defendant.

Plaintiffs' Exhibits Nos. 10, 11 and 12
(Combined and Abridged)—(Continued)

Answer: Defendant is without knowledge as to whether or not a formal notice of infringement of Letters Patent No. 2,156,519 and No. 2,161,733 was sent by plaintiffs to International Geophysics, Inc. on July 6, 1939.

108.

State whether or not, on or about September 16, 1940, Robert P. Miller delivered to Erle P. Halliburton a copy of each of the United States Letters Patent in suit.

Answer: Yes.

109.

State whether or not Erle P. Halliburton is an officer of the defendant corporation.

Answer: Yes.

110.

State whether or not, on or about September 16, 1940, Robert P. Miller notified Erle P. Halliburton orally that the defendant's methods and appartus, admitted in Paragraph IX of the answer herein, were infringements of the United States Letters Patent in suit herein.

Answer: No. Robert P. Miller discussed the patents here in suit with Erle P. Halliburton only in connection with a proposal that defendant purchase the business of the Depthograph Company, or similar proposals.

Plaintiffs' Exhibits Nos. 10, 11 and 12 (Combined and Abridged)—(Continued)

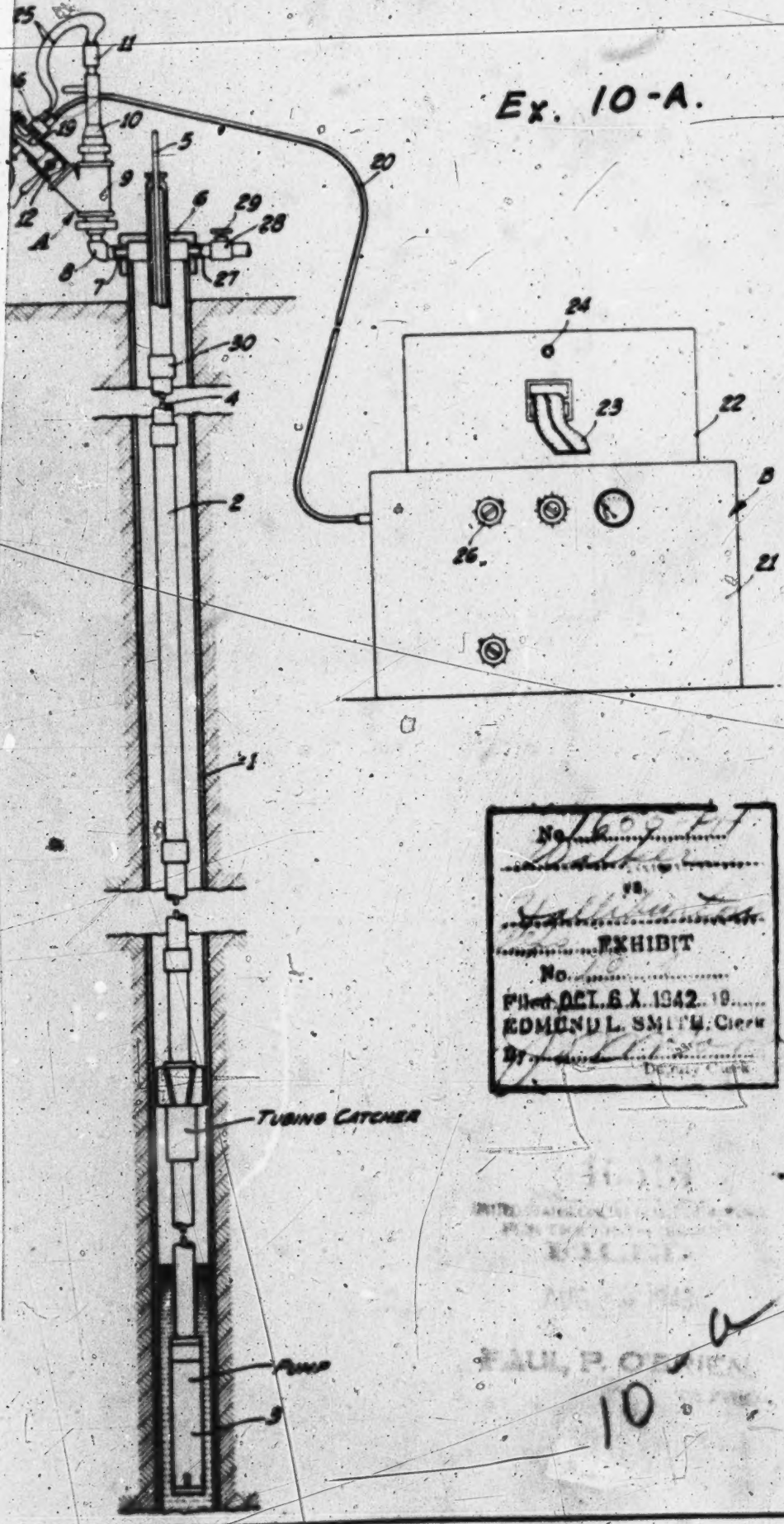
111.

State when the defendant acquired that part of its business which includes the methods and apparatus admitted by the defendant in Paragraph IX of its answer herein.

Answer: Defendant started acquiring the business referred to in February, 1938 by developing sonic fluid level locating apparatus.

[Endorsed]: Filed June 1, 1943.

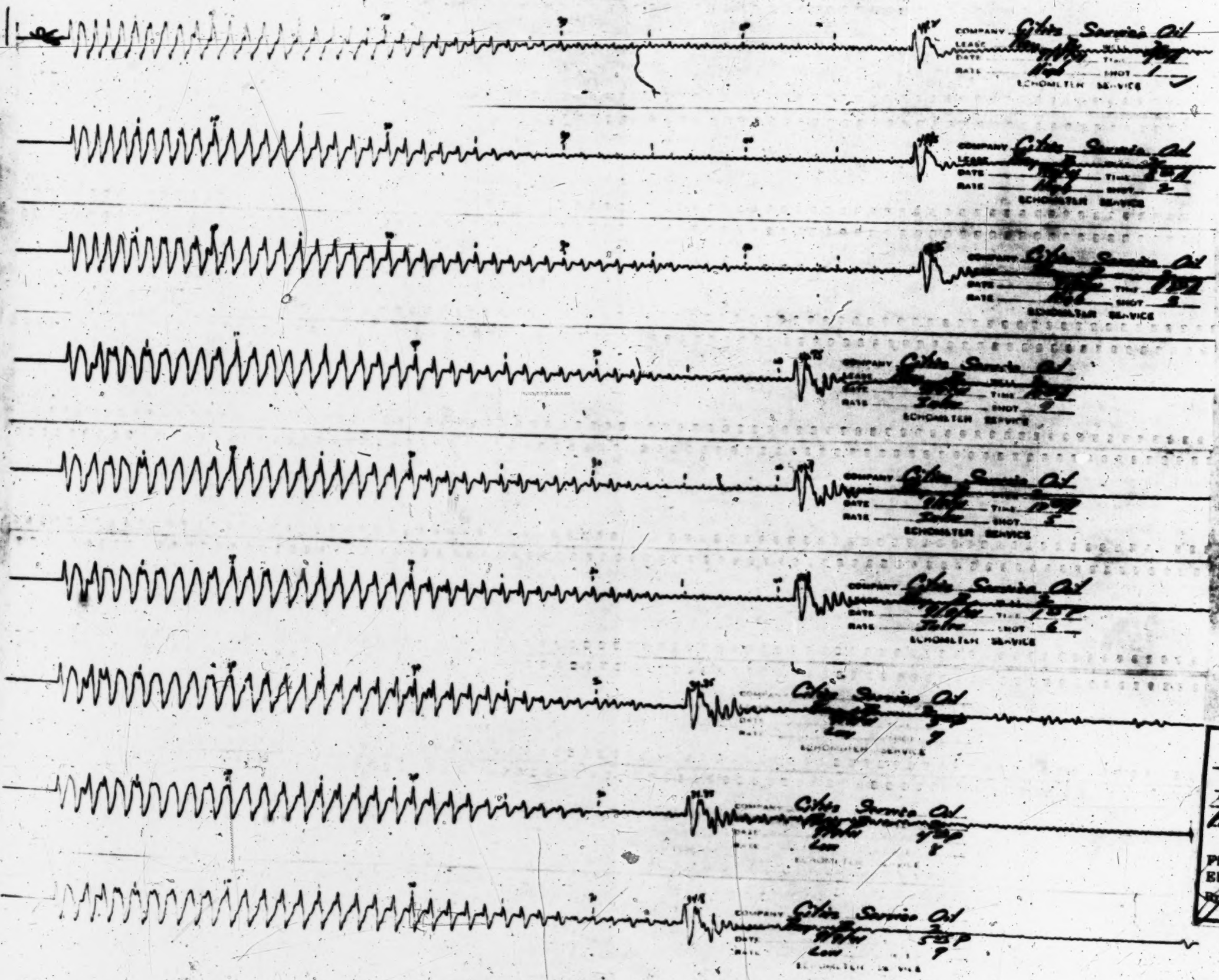
Ex. 10-A.



No. 1609 Pt
Walker
vs.
Halliburton
EXHIBIT
No. 10
Filed OCT. 6 X 1942 19
EDMUND L. SMITH, Clerk
By
Deputy Clerk

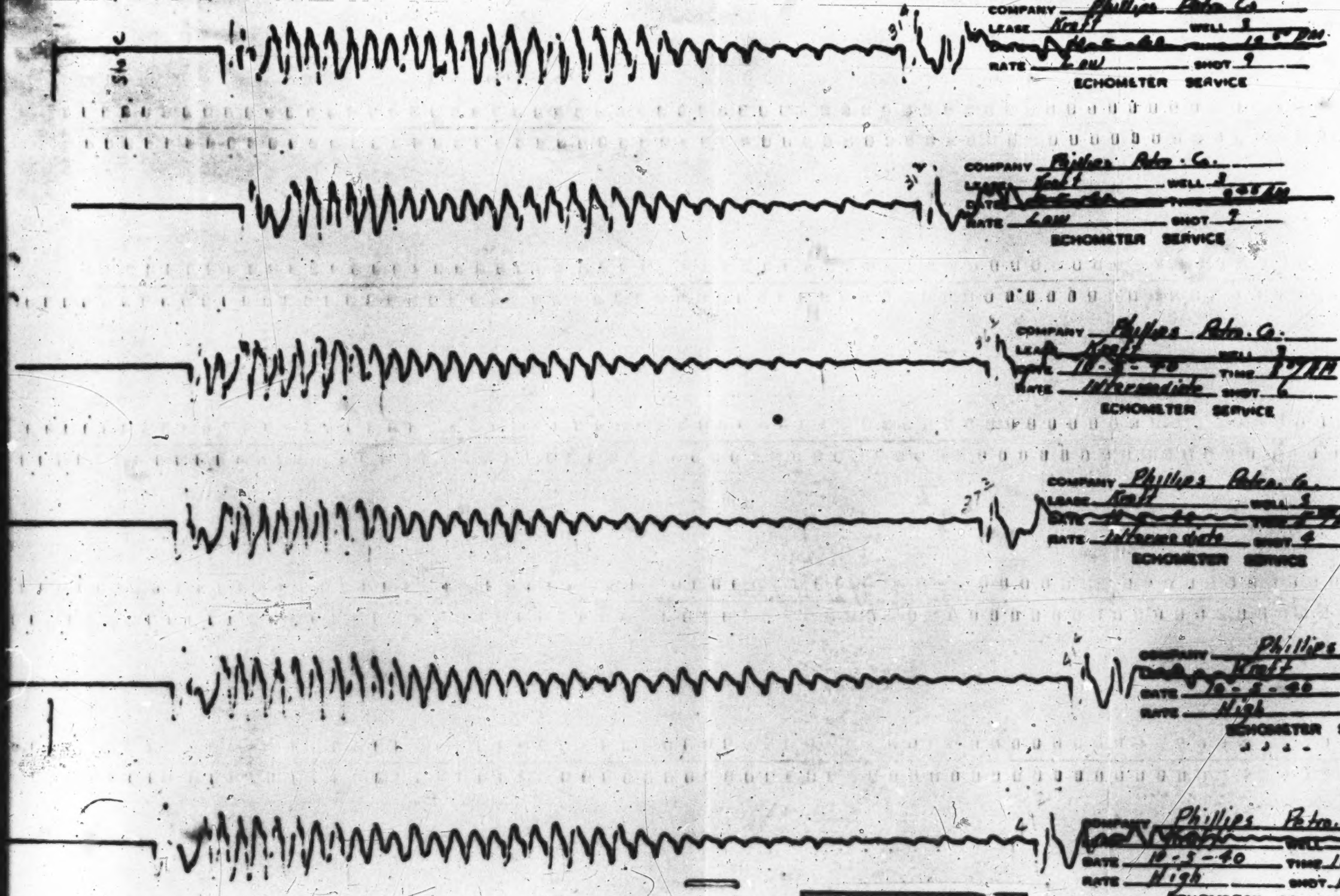
PAUL P. O'BRIEN

10-a



No. 1655-PH
Walter
vs.
Halliburton
et al. EXHIBIT
No. 10-B
Filed OCT 6 - 1942 19
EDMUND L. SMITH, Clerk
By
Deputy Clerk

Plo Ex 5



PLAINTIFFS' EXHIBIT 6

No. 1656-PH
Walker
vs.
Halliburton
Plf. EXHIBIT
No. 10-C
Filed OCT 6 - 1942 19
EDMUND L. SMITH, Clerk
By
Deputy Clerk

IN THE DISTRICT COURT OF THE UNITED STATES
SOUTHERN DISTRICT OF CALIFORNIA
CENTRAL DIVISION

CRANFORD P. WALKER: and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as DEPTHOGRAPH COMPANY, Plaintiffs,	
vs.	No. 1655 - H
HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware Corporation, Defendant.	C I V I L

DEFENDANT'S EXHIBIT NO. 16

accompanying

DEFENDANT'S ANSWERS TO INTERROGATORIES PROPOUNDED BY PLAINTIFFS

No. 1655-PH
Walker
vs.
Halliburton
EXHIBIT
No. 11-A
Filed OCT 6 - 1942 19
EDMUND L. SMITH, Clerk
By
Deputy Clerk

11-A

No. 10513
UNITED STATES CIRCUIT COURT OF APPEALS
FOR THE NINTH CIRCUIT
FILED
AUG - 3 1943
PAUL P. O'BRIEN,
CLERK

Def. Ex. 16

IN THE DISTRICT COURT OF THE UNITED STATES
SOUTHERN DISTRICT OF CALIFORNIA
CENTRAL DIVISION

CRAWFORD P. WALKER; and CRAWFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. [illegible], doing business as DEPTHOGRAPH COMPANY, Plaintiffs, vs. HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware Corporation, Defendant.	No. 1654 - H CIVIL

DEFENDANT'S EXHIBIT NO. 17

accompanying

DEFENDANT'S ANSWERS TO INTERROGATORIES PROPOUNDED BY PLAINTIFFS

No. 1655-PH
Walker
vs.
Halliburton
EXHIBIT
No. 17
Filed OCT 6 - 1942
EDMUND L. SMITH, Clerk
By [illegible]
Deputy Clerk

11-B

16,518
No.
UNITED STATES CIRCUIT COURT OF APPEALS
FOR THE NINTH CIRCUIT
FILED
AUG - 3 1943
PAUL P. O'BRIEN,
CLERK

NARRATION OF PLAINTIFFS' EXHIBIT NO. 11-C

ECHO-METER FIELD MANUAL

FOREWORD

It is the purpose of this manual to help the Echometer operator. * * * All material in this manual, together with the additional material to be forwarded from time to time, is the sole and exclusive property of the Halliburton Oil Well Cementing Company, and is being distributed for your guidance and use in rendering service to clients of HOWCO. This material is to be considered strictly confidential, and will be made a part of the inventory equipment.

Daniel F. Elam,
Echometer Supervisor.

DFE:gs
July, 1940

WELL EQUIPMENT

The Casinghead Unit

(1) The Casinghead Unit is considered an integral part of the Echometer equipment because it contains the wave-initiation mechanism and a detecting microphone, both essential to proper operation of the Transducer and the Recorder.

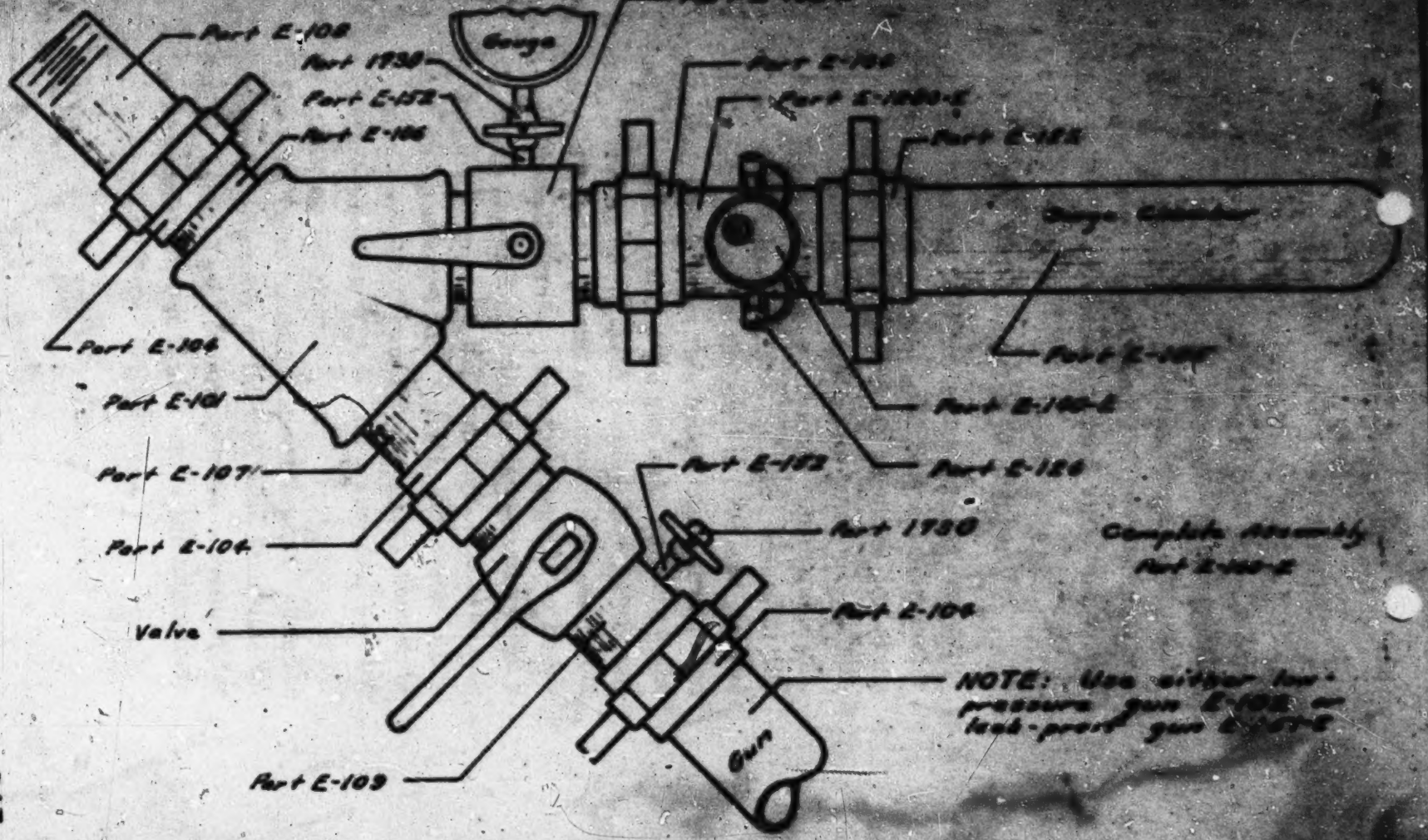
Operation

The Casinghead Unit should be attached immediately upon arriving at a well (See Drawing 7490),

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

and care should be taken to see that all joints are tight and not leaking gas. A leak at any connection, particularly at a point back of the mike, will cause a bad record due to high-frequency noises, which may obscure tubing collar reflections and even the fluid level. Any gas lines leading from the casing should also be shut in, or disturbing acoustical effects may result.

The method of loading and firing the Echometer gun is obvious upon inspection. Make certain, however, when using 10-gauge blanks that the butterfly valve (part E-130-E) which protects the microphone is closed for the shot (handle in line with gauge). A small hole in the disc of this valve passes enough wave energy to record the shot signal and the first few tubing collar reflections, but the valve should be opened (in line with surge chamber) soon After the shot in order to admit the weaker and deeper collar reflections. Whenever the fluid level is high and little sound energy is needed to obtain a record, a .38 calibre blank may be fired by using an adapter bushing in the (2) gun. In this case the butterfly valve may be left open and no damage will result to the mike, because of the smaller explosion.



Revised by RWC Date 5-7-42 Revised by Date	PARTS LIST AND ASSEMBLY ECHOMETER CASINGHEAD UNIT HALLIBURTON OIL WELL CEMENTING CO. - Duncan, Ok.	Drawn by Checked by Date Drawn No.

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

An electric cable, with 4-pin Jones plugs, makes the necessary connection between the detecting microphone, signal light, and instrument equipment. This plug must be attached to the terminal box (Part E-140E) on the casinghead unit, and to the Transducer cabinet. * * * (3)

The Valve and Gun Mechanism

At the present time there are two general types of Echometer guns in use. The original Winchester salute cannon (Part E-102) is adequate for areas where wells of low casinghead pressure are encountered. However, if the wells make considerable gas, an undesirable leak around the shell occurs at the gun breech until after the shell is fired and its case expanded, which stops this leak. Since production men in general try to avoid gas leaks on their wells, they therefore hesitate to employ any equipment which deliberately creates this undesirable condition. A bad leak also causes premature signals to be recorded and makes it difficult for the operator to set a proper initial gain on his amplifier. To overcome these disadvantages, the special Echometer high-pressure leak-proof gun (Part E-151) should be used, in connection with a plug valve and bleeder. (See drawing 7490).

The plug valve renders it unnecessary to close the permanent gate valve on the well head each time for gun reloading. This not only is more convenient for the well assistant, but it also leaves the microphone

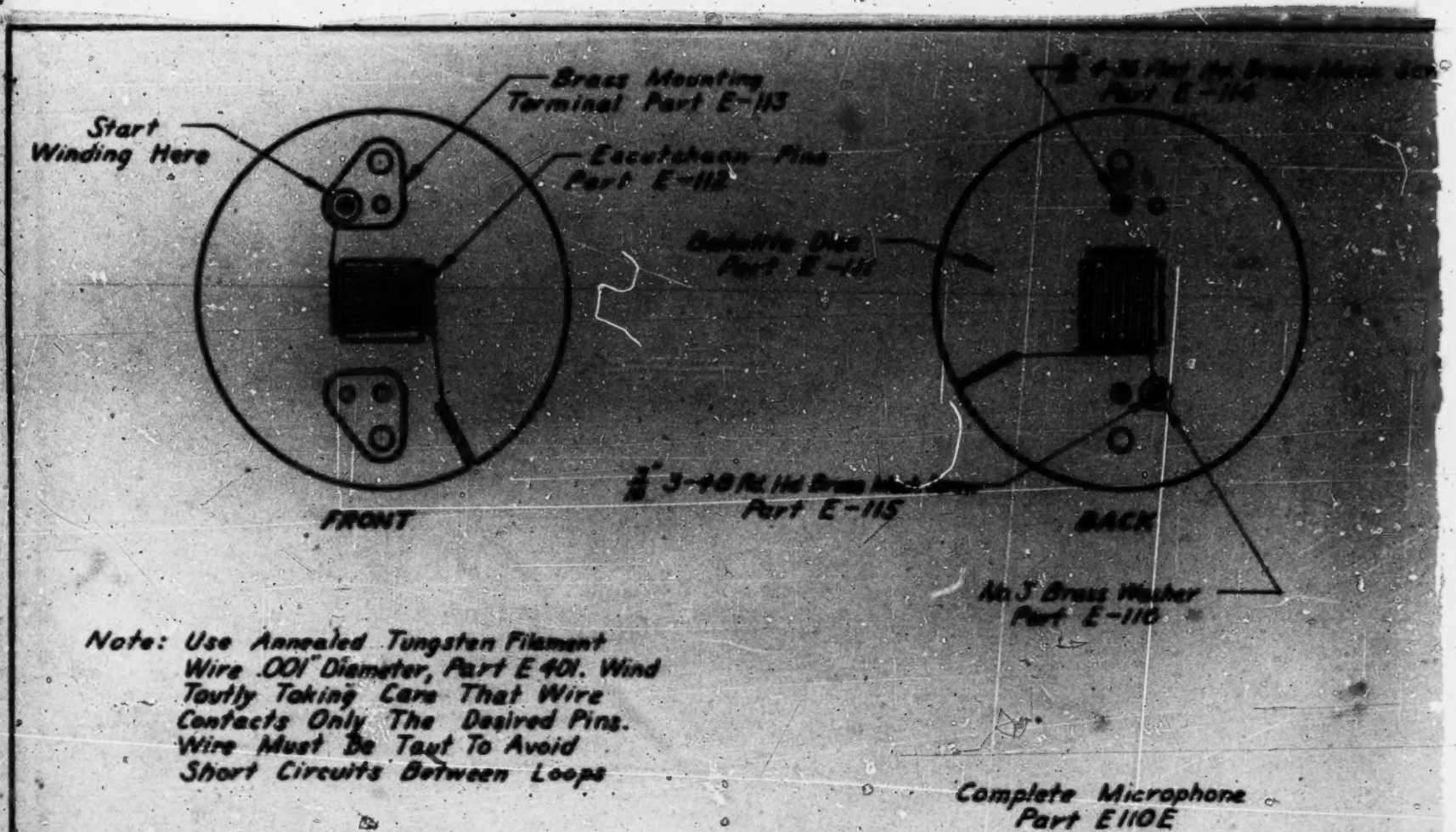
Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

at a constant pressure throughout the series of measurements, thereby eliminating (4) possibilities of damage due to bleeding and re-pressuring the entire Casinghead Unit after each shot. * * *

It can therefore be seen that the use of a plug valve and a leak-proof gun are essential to the smoothness and efficiency of well operations whenever gas is encountered.

The Microphone

The conventional type of microphone does not possess the desired frequency response for Echometer work. After considerable experimentation, a modification of the hot-wire microphone developed by Tucker during the World War has been employed. The system comprises, essentially, an electrically heated thin strip conductor and a means of producing a small blast or movement of gas past it. Our adaptation of the microphone has a frequency characteristic which allows it to successfully pick up frequencies from a fraction of a cycle per second to above 40 cycles per second. This range is sufficient to cover any application to Echometer work. The microphone as it is used is used as a velocity apparatus, actuated primarily by the movement (5) of the gas past it. Other types of detectors (such as that used in Depthograph apparatus) are sensitive only to changes in pressure.



Note: Use Annealed Tungsten Filament Wire .001" Diameter, Part E 401. Wind Toutly Taking Care That Wire Contacts Only The Desired Pins. Wire Must Be Taut To Avoid Short Circuits Between Loops

R. 725.

650	ECHOMETER MICROPHONE WINDING AND PARTS ASSEMBLY	Drawn By O.R.S.
	HALLIBURTON OIL WELL CEMENTING CO., Duncan, Okla.	Date 6-7-40
		No. 7458

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

Construction

The mounting of the microphone is a circular disk, made of Bakelite, in which a hole has been cut from the center (See drawing 7458). In addition to winding pins are the necessary anchor screws to hold the thin wire conductor and two mounting holes for attaching the microphone to the casinghead unit.

"Winding" a microphone is very important, as its electrical characteristics should be fairly constant. (Drawing 7458). Tungsten wire 1-mil (1/1000") in diameter is used. This wire is anchored under the set screw on the front (as the microphone rests in the Casinghead Unit) and is strung back and forth over the pins on the face of the mounting. The last pin over which the wire passes should be beside the diagonal slot. Pass the wire through the slot and continue the winding on the back of the mount, securing the end of the wire with the anchor screw. Approximately 80 cm. of wire constitute the active part of the grid. Proper operation of the equipment cannot be obtained if the grid wire is too long or too short. * * * (6)

Electrical Characteristics

The windings on the microphone have a resistance of about 80 ohms at atmospheric temperature, but when current is passed through the windings their resistance is markedly increased (to about 200 ohms). Herein lies the secret of microphone operation. The reflected waves from the tubing collars, which pass across the windings of the microphone,

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

have a cooling action on the hot wires, changing their resistance and thereby introducing a very small signal to the input of the amplifier. This signal is amplified from a very small current variation to a level high enough to operate the direct-writing Recorder.

The microphone current is furnished from one or more "B" batteries, connected, by a 3-pin Jones plug to the amplifier chassis. A master control on the chassis closes the circuit when switched to "Mike" position. Current values are read directly on a meter mounted on the amplifier panel, and should be about 200 milliamperes at atmospheric conditions. * * * (7)

It has been found that the use of a long surge chamber (Part E-105)—which greatly increases the sensitivity of the microphone—often will produce spurious indications on the record. For this reason, a short chamber (one or two feet in length) is used back of the grid to pick up the tubing collar reflections. * * * Do Not Attempt to Use Any Sort of Acoustical Tuning.

Patents (8)

Specification and Constructional details of the grid-type detectors are given in U. S. Patent No. 1,351,356, issued August 31, 1920 to William S. Tucker. (9)

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

INSTRUMENT EQUIPMENT

* * *

Principle of Operation

There is no mystery about the sound initiation. The firing of the special cartridges simply creates a steep-front wave, which has high frequency components and a superimposed velocity due to the expansion of gas used for creating the wave. Any frequencies coming from the well above 50 cycles are not picked up by the microphone; those below 10 cycles are rejected by the transducer. Therefore, the Echometer faithfully reproduces and records only the frequencies coming from the well over a relatively narrow band. Tubing collars, mid reflections, liner reflections, etc., fall within this band.

Voltage supply for the transducer is a 6-volt storage battery. * * * Power for the recorder motor is furnished by 12-volts, or two storage batteries in series. * * * (10)

Schematic drawings Nos. 7515 and 7531 show the Echometer Transducer and Recorder circuits. * * * (11)

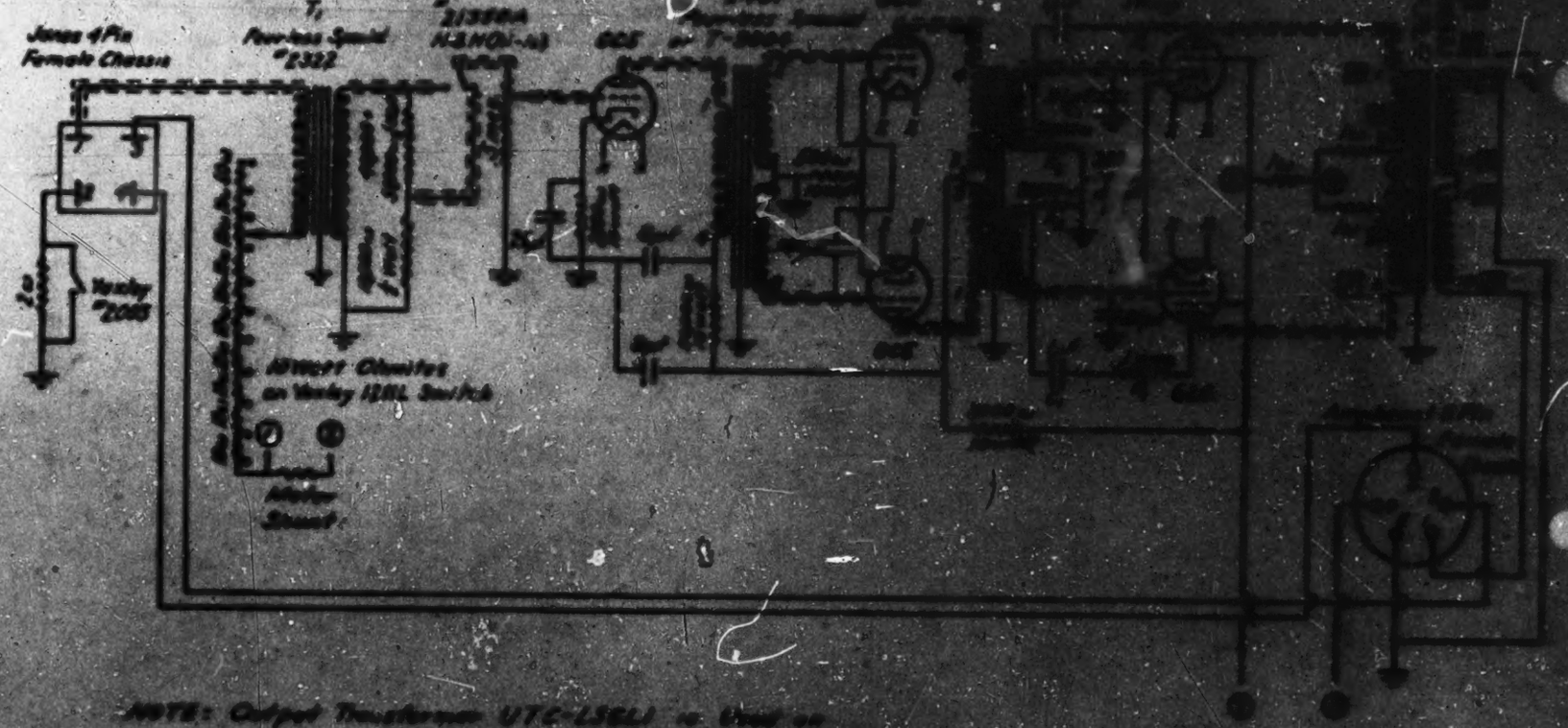
The Transducer

Operation

The transducer is turned on by placing the Master Control at "Fil" position. This causes the filaments of the tubes to heat, and requires about thirty seconds. If the tubes have not sufficiently warmed, when the switch is turned to "Power" for recording, the indicating meter will not read the normal

Narration of Plaintiffs' Exhibit No. 11-C
(Continued,)

operating current of about 90 milliamperes, but will gradually rise to this value as the tubes become warmer. A jeweled indicating reflector is lighted when the transducer switch is in any position besides "Off".



NOTE: Output Transformer UTC-LSCLI is Used on Instrument 44 and after. Dotted Portion Indicates Additional Winding For Use With Filter. Numbers in Squares Indicate Connections.

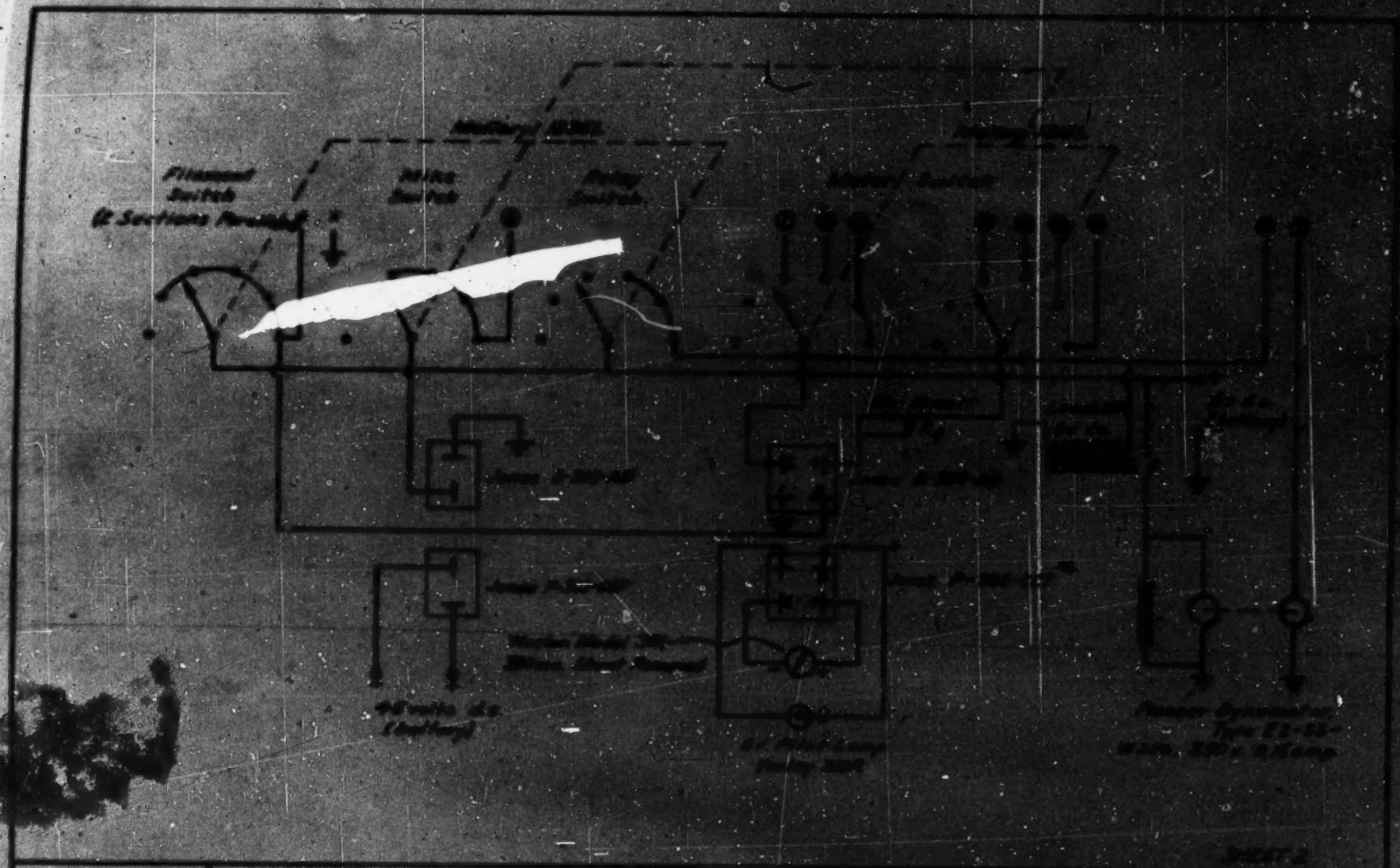
SHEET 1

654

SCHEMATIC OF ECHOMETER AMPLIFIER

HALLIBURTON OIL WELL CEMENTING CO. DUNCAN, OKLA.

Drawn by [illegible]
Checked by [illegible]
Date [illegible]
No. [illegible]



655

SCHEMATIC OF ECHOMETER AMPLIFIER

HALLIBURTON OIL WELL CEMENTING CO. DUNCAN, OKLA.

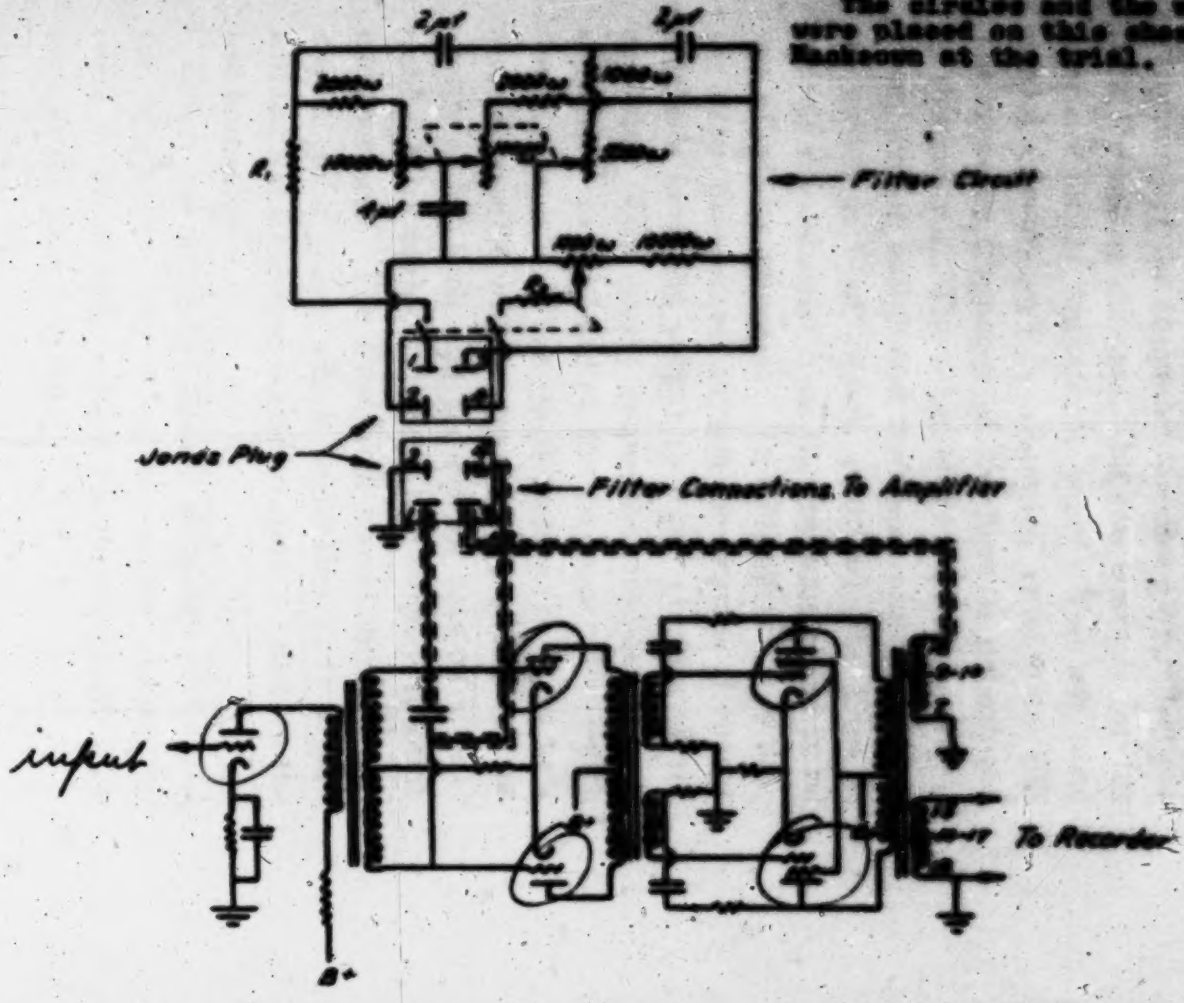
Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

The "Mike" tap is placed between "Fil" and "Power" in order that the operator can observe the electrical character- (12) istics of the microphone immediately before and after each shot. (See Drawings 7531). * * *

When the Master Control is in "Power" position, the output of the transducer is fed into the ink recorder. It is in this position that the instrument operates. "Plate 1" and "Plate 2" are testing taps that should be employed at the beginning of each day's work. When the control knob is turned to "Plate 1" the meter on the panel indicates the plate current in the first output tube (6L6), which should be approximately one-half the total current flowing in both tubes at "Power" position. Similarly, "Plate 2" should read about one-half the total current. * * *

To increase or decrease the magnitude of the reflections (13) recorded, a "Gain" or "Amplitude" control is provided. It is located on the transducer panel, and is calibrated from 0 to 100. Conveniently located is a "Hi-Low" switch in series with the "Gain" control. The "Hi" side with approximately 10 times the amplification of the "Low" side, is in effect extending the scale from 100 to 1000 arbitrary units.

The circles and the word 'input' were placed on this sheet by Mr. Ransom at the trial.



133	SCHEMATIC OF ECHOMETER ELECTRICAL FILTER	Drawn By O.R.S.
	HALLIBURTON OIL WELL CEMENTING CO. DUNCAN, OKLA.	Checked By [illegible]
		Date 6-12-40
		No. 7506

734

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

Operation of Filter

* * * Drawing No. 7506 is a schematic of the circuit.

The electrical filter is designed to filter and selectively amplify the frequency produced by reflections from the tubing collars. The two controls for the filter are on the transducer panel. The left hand control (Frequency) is calibrated from 0 to 100. The response frequency of the filter is determined by this control. The other control (Decrement) is a combination switch and feed back control. When the switch is "Off" (zero position), the filter is entirely disconnected from the transducer and in no way affects its operation. In addition to its switching action this control adjusts the amount of energy fed back from the output to input circuits of the amplifier. This energy causes the amplifier to have a tendency to oscillate at the frequency for which the filter is set. When the decrement is set as near zero as possible without turning the switch off, no energy is fed back and the circuit acts as a filter alone. With higher settings the tendency to oscillate increases. The Feed-back should never be increased to a point where oscillation (14) occurs without some exciting signal to start it (such as the test button).

Before operating the filter it should be calibrated for frequency. The most convenient calibration curve is one of filter setting vs. record length of a cycle of the filter frequency. * * *

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

When using the filter on a well, one record should always be made in the usual manner with the Decrement turned "Off". By measuring as many tubing collars as possible on this record the average joint length on the record is then determined. The collars measured should preferably be in the (15) deeper parts of the well to avoid any abnormal shortening at the start of the record. Then, referring to the calibration curve for the filter, the setting corresponding to this record length of frequency inasmuch as variations in the recorder motor speed will change the apparent frequency of the filter. If there is any doubt about the filter setting, it may be checked by starting oscillations with the test button and comparing the length of the cycles with the tubing collars on the record from the well. The setting should be as close as possible. Otherwise, beats will appear in the record when the filter is used. Also, if there are any very large variations in either joint length or velocity in the well, it may be difficult to avoid getting beats with the filter. Always compare the filtered with the unfiltered records before leaving a well.

When the feed-back control is set at zero the frequency response of the filter should be a little broader. For this reason the Decrement control should be operated at the lowest practical setting. In wells where the collars are very weak increased feed-back will help to bring out the weak collars. Extreme care must be taken never to set the feed-

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

back so high that artificial collars will be produced. If this is done the calculated fluid depth may be in error, if the frequency setting of the filter is not exactly the same as the collar frequency of the well.

When it is difficult to get good collars the feed-back control should be set so that when the transducer volume control (16) is set at the maximum necessary for the well the push button will cause the filter to generate oscillations for not over 10 cycles. The filter will give the transducer an over-all amplification somewhat greater than normal for signals of the frequency for which the filter is set. This amplification increases as the feed-back is increased. The filter will have a tendency to decrease the sharpness of the fluid, tubing catcher, and liner top breaks on the record and in some cases it will be necessary to record these points on one record without the filter and then use the filter to improve the tubing collars on the record. * * *

FIELD OPERATION

Obtaining Records

(19) A suggested operating procedure for general field conditions follows:

1. Supervise the attaching of the Casinghead Unit, and see that all valves, flow lines, etc. on the well are properly prepared. Install a new microphone and connect the mike cable from the Transducer. Close the plug valve (part V-111) and Slowly open the gate valve at the well so as not to

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

place undue strain on the mike or on any accidentally loose connections. Load the gun, and Then Open the Plug Valve. * * * *

2. Turn on the "Fil" of the Transducer and permit the tubes to heat. * * *

3. Rotate master switch to "Mike" (or "Grid") position and check the mike. * * * Set the grid current as previously explained.

4. At the first shot each day, check the plate currents at "Power" "Plate 1" and "Plate 2" positions. (See "Transducer-operation").

5. Return master switch to "Fil" and arbitrarily set "Gain" or "Amplitude" to 50 "Lo", or to some other value chosen after obtaining a small kick of the recorder cylinder by using the test button.

6. Start the recorder motor. * * * (20)

7. Make certain the plug valve in front of the gun is Open to the well; then signal for the shot. Your attendant at the well will fire the gun, close the plug valve, bleed off the gas, and re-load for another record.

8. Be prepared to increase or to decrease the "Gain" as you observe the recording from the shot. From the experience of this first record, better manipulation of the instrument will result on subsequent shots. Always, however, start with a low gain and increase the control as the deeper well reflections become naturally weaker. The recorded signals should be approximately of uniform magnitude along the entire length of the record. * * * *

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

9. If disturbing high-frequencies are present on the record, or if the tubing collars are not clear, the filter may be used to clean up the record. Obtain a proper filter setting from the calibration curve and compare the filtered and unfiltered records before leaving the well. (See section on "Operation of Filter".) * * * * (21)

Computation of Records

* * * *

By Collar Count

In the normal use of Echometer equipment, the gun will be fired into the casing annulus. Therefore, each joint of casing and tubing exposed above fluid will tend to slightly obstruct the sound wave, and will cause small impingements to reflect back to the microphone at the casinghead. Since the magnitude of these reflected waves is depending upon the per cent change in (22) cross-sectional area of the annulus, it can be seen that reflections from casing joints are inferior in magnitude, or signal strength, to those caused by tubing couplings and therefore will not be discernible. Thus, when the instrument is so adjusted as to record "tubing collars", either a tubing tally or an average length of joint for the well can be used for computation purposes. However, the accuracy of the computation from these collars is limited by the reliability of the tubing tally, or average joint length submitted by the client. * * *

Narration of Plaintiffs' Exhibit No. 11-C (Continued.)

Under average conditions, each exposed joint of tubing will be indicated on the Echo record, and the depth to fluid can be interpolated to the nearest 0.1 of a joint. Long subs at the top are usually indicated, and a tubing string of mixed joints will normally show the relative joint lengths and sizes.

By Graphic Extrapolation

Whenever tubing collars cannot be recorded all the way to the fluid, a close approximation of the fluid depth can be had by extrapolating the deeper collars on the record. Perhaps the best manner of doing this is to plot the "measured length of record" (Time) against "well depth in tubing collars" (Distance). The resulting graph will show velocity of the sound wave in this particular well. A line through the deeper collars can then be extrapolated to a point representing the measured length to fluid, and will show the fluid depth in terms of tubing collars. (23)

Due to possible "abnormal" velocity changes near the top of the well (as explained under "Calibration Procedure") only the deepest recorded collars should be used for extrapolation purposes. Top collars may be recorded shorter, due to a higher wave velocity, and thereby if used will give a fluid level that is too deep.

By Well Velocity

Whenever the fluid level is below some recognizable well point, which has a known depth, (a tubing

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

catcher, liner top, or gas-lift flow valve), no appreciable error is involved if depths are computed by proportional measurement of record lengths, as:

$$\frac{\text{Length of record to catcher}}{\text{Length of record to fluid}} = \frac{\text{Depth in feet to catcher}}{\text{Depth in feet to fluid}}$$

This is, in effect, computing the fluid depth by extrapolating an assumed constant well velocity. The cumulative error is minimized because of the small distance which is extrapolated. * * *

(35) FIELD PROCEDURE

Subsurface Pressures

The subsurface pressure gauge graphically records the total maximum pressure at any desired datum, but in Echometer work the component parts of this total pressure are measured and the sum is computed mathematically, as all the factors involved are technically subject to measurement.

The bottom hole pressure is the sum of the casinghead pressure (P_{ch}), the weight of the gas column (P_g), and the weight of the fluid column. The weight of the gas column can be determined if its length, specific gravity, average temperature, deviation from Boyle's Law, surface pressure, etc. are known. The weight of the fluid is equal to its height (h) times the average density (d). Mathematically, the bottom hole pressure may be expressed:

$$P_{bh} = P_{ch} + P_g + hg \qquad (1).$$

The pressure on the well casinghead can be gauged

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

at the time of the shot initiation. The Echometer record obtained is itself a measure of the length of the gas column. The specific gravity of the casing gas is easily and quickly determined with a postable measuring apparatus. (In ordinary field operation, the effects of temperature, deviation, etc. are of minor importance.) By subtracting the depth to fluid from the depth to the desired pressure datum, the height of the fluid column exerting pressure will be obtained. Substitution of the observed and calculated (36) values can then be made in equation (1).

Specific Gravity of Gas

The specific gravity of the casing gas can best be determined in the field by use of a Schilling bottle, following instructions of the manufacturer. * * * * (37)

Use of Formula or Gas Charts Based Thereon

The basic equation for obtaining the weight of a column of gas under pressure is known as the Dice formula:

$$\text{Log}_{10} P = \frac{SH}{122.82\ (t + 460} + \text{Log}_{10} p \qquad (38)$$

where P is the total absolute pressure at the base of a gas column and p is the absolute pressure at the top of the column. S is the specific gravity of the the gas and H is the length of the column. The average Fahrenheit temperature of the gas is designated by t.

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

To render this formula more usable in the field, it has been solved and the results plotted as gauge pressures on four charts (not in printed record).

* * * *

Fluid Density and Fluid Pressure Gradient

In cases where a low gas/oil ratio exists, or where the oil produced is extremely heavy, little error will result if a uniform fluid gradient is assumed in the well and the effects of gas are neglected. On simple draw-down capacity tests, "feet of (39) fluid" may be plotted directly against "gross rate of production" to indicate the well's potential. Likewise, "feet of fluid" multiplied by the gradient gives the subsurface datum pressure.

In computing shut-in subsurface pressures, the average fluid density is generally known from previous experience in a particular field and can be correctly assumed. If necessary, however, measurements can be plotted for the changes in equilibrium fluid height at two or more different casinghead pressures and an extended line drawn through these points—thereby determining the casing pressure necessary to depress the fluid to any desired depth. When the fluid has been thus theoretically removed above the datum, the bottom hole pressure must be in equilibrium with the total pressure of the gas above. Therefore, the weight of the theoretical gas column at desired depth plus the casinghead pressure as determined by extrapolation to that depth

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

will equal the datum pressure. This same procedure may be employed to determine producing subsurface pressures by keeping the production rate constant during a series of back-pressure measurements.

In wells producing gas, the fluid gradient in the annulus of the well depends not only upon the producing conditions but also on the effective area of the annulus. For given producing conditions, the fluid gradient in the annulus is assumed constant from the top of the fluid to the perforation, provided there is no change in casing size. It has been found that the gradient varies from about 0.05 to 0.5 pounds per square inch pressure per foot of depth below the fluid level, depending upon the gas/oil ration. * * * (40)

Normally, the Echometer operator will be responsible for the field work only, and will fill out merely the columns pertaining to such, as: Lease, well number, time and date, joints to fluid, casing-head pressure, production, and remarks. Such data as the average joint length, feet to fluid, datum elevations, pressures, etc., should be furnished or completed by the client. However, it is always a good policy to supervise the averaging of tubing tallys, method of pressure computations, etc. to be sure the client is handling the data properly and without difficulty. * * *

Determination of Subsurface Pressure

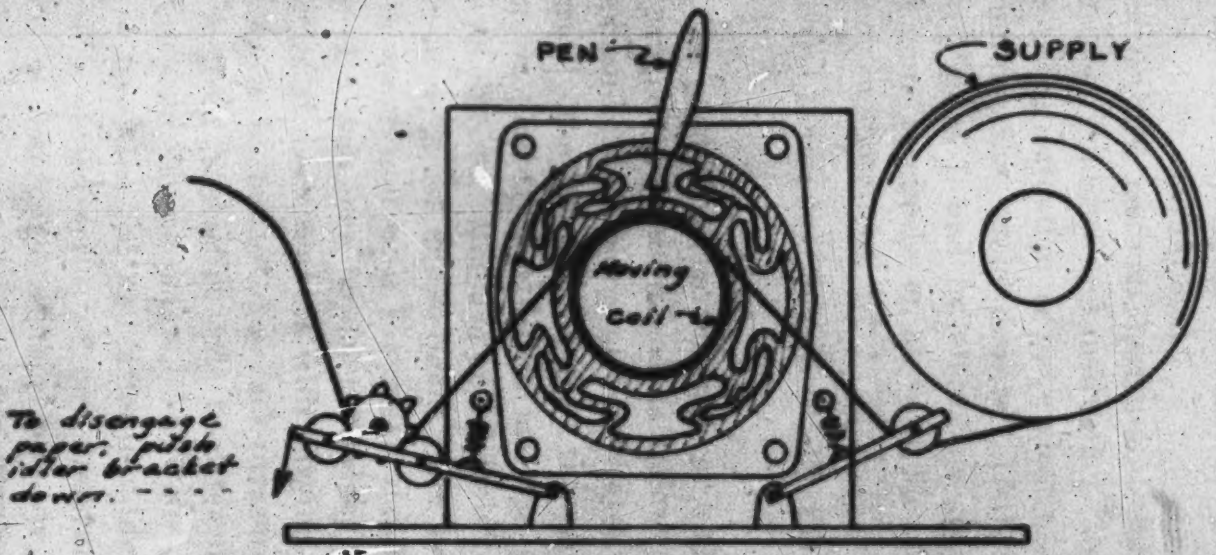
The original bottom-hole pressure, and its rate of decline, are of considerable importance to the pet-

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

roleum engineer. These data may be obtained by direct measurement with a subsurface pressure gauge or they may be calculated from the known relationships of fluid level, casing-head pressure, and rate of production.

A plot of fluid-level data with h as ordinate and total gas pressure on the fluid as abscissa is a straight line, provided the production rate is held constant and the density does not vary with depth. Hence, the pressure at the reservoir dept., P_1, may be obtained by extrapolation. This method of computation illustrated in Figure 1, is patented by a competitor, and should not be used.

A more rapid method which is free of any patent litigation and which involves the determination only once of the weight of the gas column is illustrated in Figure 2. The production rate is maintained constant and two or more measurements are made of fluid levels versus casinghead pressure. Extrapolation of the data to the depth of the mean producing horizon gives the theoretical casinghead pressure necessary to force the fluid-level down to the producing horizon. The total pressure at this depth may be obtained by adding the weight of the gas column at that depth to the extrapolated casinghead pressure. Referring to the figure, the extrapolated casinghead pressure was found to be 258 pounds, while the calculated weight of the gas column was 47 pounds; giving a total formation pressure of 305 pounds.



DETAIL OF PAPER TRAVEL

PLATE III.

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

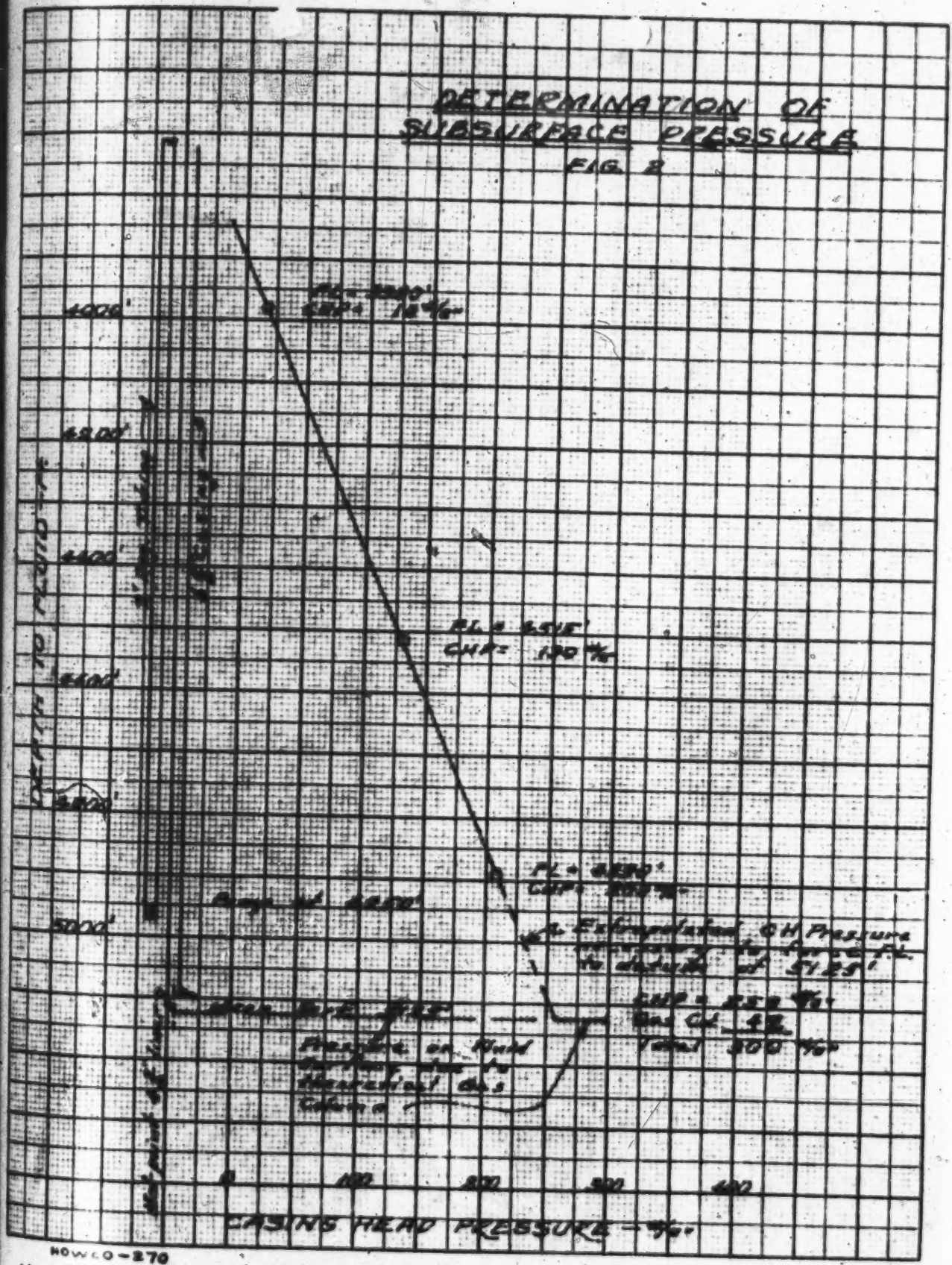
The competitive methods herein illustrated are shown for your guidance and instruction. However, until the patent situation is more clearly defined, do not imitate the "fluid density" (50) method shown in Figure 1, and by all means do not allow your name to appear on any graphical density or gradient computations. * * *

Productivity Determinations in Wells Producing Gas

(58) The producing characteristic of wells making gas can best be determined as follows:

The bottom-hole pressure, at some given datum point—usually the average depth of the producing formation, is plotted as ordinate and the production rate as abscissa. Methods of determining total pressures at a given datum point have been described in connection with Figures 1 and 2. Productivity of a well may be determined by making such a series of measurements with varying casing-head pressures by means of a back-pressure regulator at a given production rate to determine one of the pressure datum points. The rate of production is now changed and after equilibrium is established a second series of measurements (58) are made to determine another pressure datum point. Two or more of such points are then plotted, and the pressure curve extra-polated to zero pressure (where no back-pressure will be exerted against the producing formation) to determine the theoretical maximum production rate for the well. * * * *

671

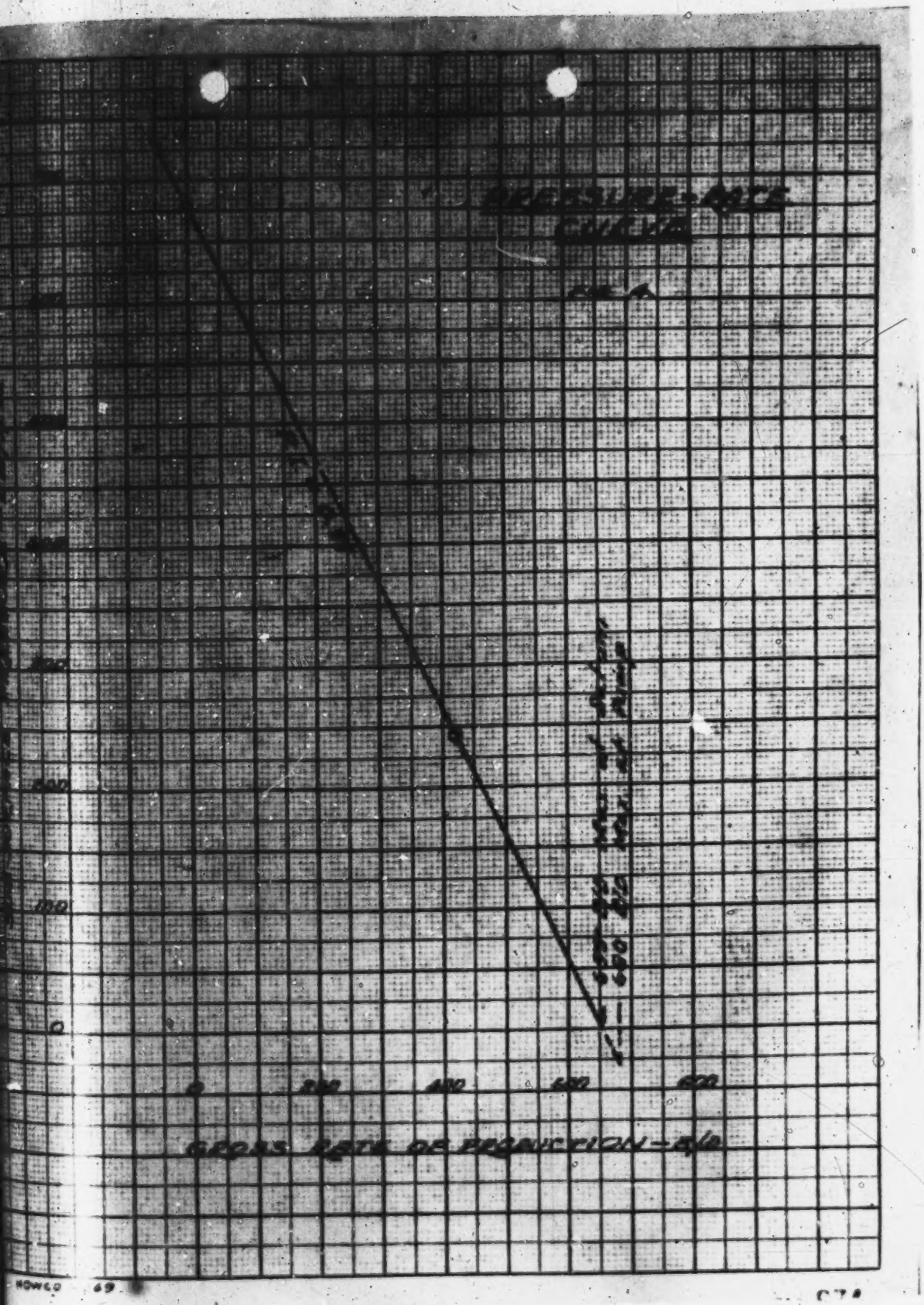

DETERMINATION OF
SUBSURFACE PRESSURE
FIG. 2
4000'
4200'
4400'
4600'
4800'
5000'
DEPTH TO FLUID - FT.
0
100
200
300
400
CASING HEAD PRESSURE - #/□"

HOWCO-270

Narration of Plaintiffs' Exhibit No. 11-C (Continued.)

The Productivity Index

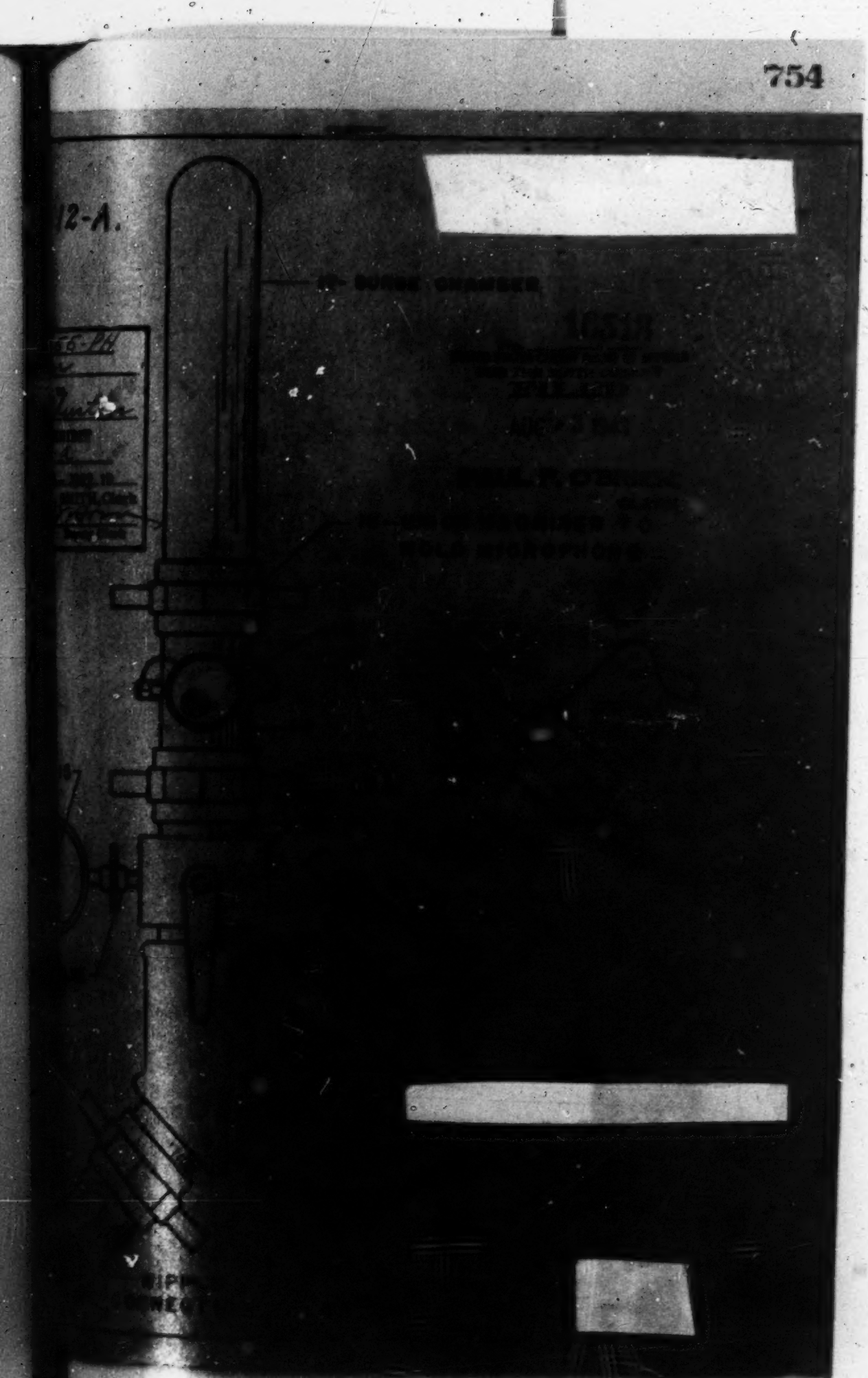
The productivity index is determined from the slope of the pressure-rate curve, (See Figure 4) and is defined as "the barrels per day of gross liquid produced per pound per square inch pressure drop at a specified subsurface datum."


GROSS RATE OF PRODUCTION - B/D

Narration of Plaintiffs' Exhibit No. 11-C
(Continued.)

Any condition tending to change the productive capacity (59) of the well is indicated by a change in the productivity index or slope of the curve. A decreasing productivity will be obtain when the gross production per pound drop in bottom-hole pressure decreases. This condition may be caused by increasing water, a decrease in effective permeability of the oil formation adjacent the well, or by drainage interference from offset wells. In some cases an increased productivity factor may be obtained, especially if the well is cleaning out or channeling. Periodic measurements of this type are a vital necessity in keeping a close check on a well's performance. The decline of a well's potential and its proper pumping conditions can be intelligently followed, and in many cases controlled, by the use of bottom-hole pressure or fluid-level data.

[Endorsed]: Filed June 1, 1943.


12-A.

vs.

EXHIBIT

K

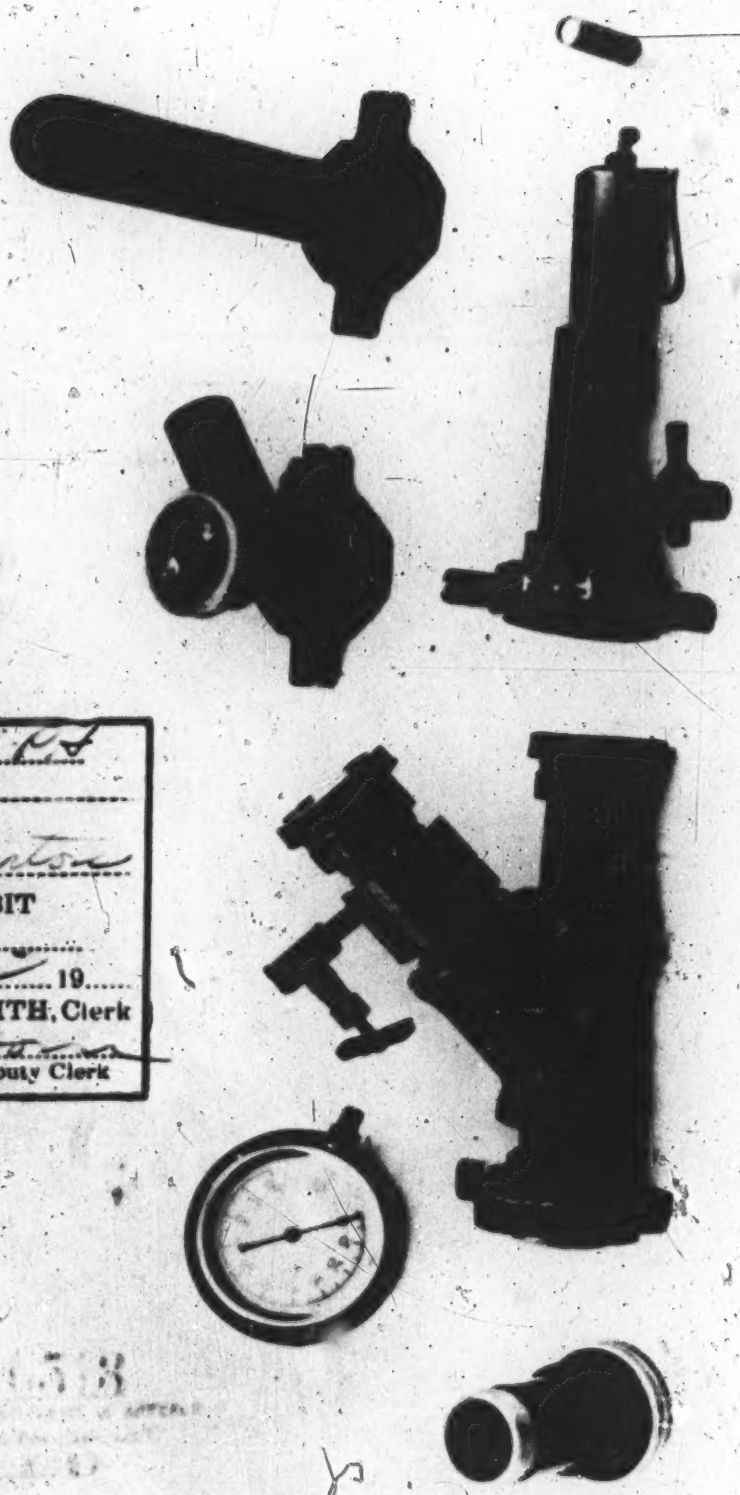
19

D L. SMITH, Clerk

Deputy Clerk

EX. 12-B.

R. 755.



No. 1630 P.F.
Wilkes
vs.
Halliburton
P.F. EXHIBIT
No. [illegible]
Filed [illegible] 19
EDMUND L. SMITH, Clerk
By [illegible]
Deputy Clerk

Notary Public

DEFENDANT'S EXHIBIT NO. 22.

Edward Gene Spain
Notary Public

No. [illegible]

vs.

EXHIBIT
No. 22-E

Filed [illegible] 19[illegible]
EDMUND L. SMITH, Clerk
By [illegible]
Deputy Clerk

FREQUENCY - Dial Divisions
AVERAGE LENGTH PER CYCLE - MM

PLAINTIFFS' EXHIBIT No. 13

District Court of the United States, Southern District of California, Central Division

Civil

No. 1655-PH

CRANFORD P. WALKER; and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as DEPTHOGRAPH COMPANY, a co-partnership,

Plaintiffs,

v.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Defendant.

STIPULATION AS TO CERTAIN FACTS

Plaintiffs and defendant herein, by their respective counsel, hereby agree and stipulate for the purposes of this trial, that the following facts are true:

That United States Letters Patent No. 2,209,944, No. 2,156,519 and Reissue No. 21,383 were issued by the United States Patent Office to the plaintiff Cranford P. Walker and that plaintiff Cranford P. Walker is the owner of the entire legal title to each of them.

That plaintiff Depthograph Company is a co-partnership comprised of Cranford P. Walker, Dorothy

A. Walker, Robert P. Miller and Milo C. Ketchum and is the sole and exclusive licensee under each of said Letters Patent.

That plaintiffs reside within the County of Los Angeles, State of California, and within the Southern District of California, Central Division.

That plaintiff Depthograph Company is operating a business, substantially the sole activity of which is the furnishing of a service for oil well operators consisting of:

(1) measuring the location of fluid levels and other obstructions and apparatus in oil wells;

(2) the measurement and computing of pressures existing at various points in the liquid column in an oil well from the surface of the column to the bottom of the well bore, known to the trade as "sub-surface pressures";

(3) the measuring and computing of the density of the liquid column, known in the trade as "fluid density determinations and fluid gradients"; and

(4) the determination of the maximum production capacities of which the wells are capable (known in the industry as "production capacity determinations", "well potentials" or "the productivity index of a well");

and that substantially the entire income of plaintiff Depthograph Company is derived from the sale of this service.

The defendant is engaged in many and various

activities in the oil industry and while defendant has made, leased and used apparatus for measuring the location of obstructions in wells and has practiced the method of:

(1) measuring location of fluid levels and other obstructions and apparatus in oil wells;

(2) the measuring and computing of pressure existing at any point in the liquid column of an oil well from the surface of the column to the bottom of the well bore; and

(3) the determination of the maximum production capacities of which wells are capable;

and is continuing to do so, defendant derives the major portion of its income from activities and services other than those complained of in this case.

Certain Facts Relating to the Prosecution of Applications Resulting in Patent 2,209,944

That Walker application Serial No. 270,865 (Defendant's Exhibit D-1) was filed April 29, 1939 and was a division of Walker application Serial No. 162,699 (Defendant's Exhibit D-12) which was filed on September 7, 1937, and that application Serial No. 270,865 is entitled to relate back to and have the effective filing date of September 7, 1937.

That on August 23, 1939 Harold W. Mattingly, Walker's Los Angeles attorney, wrote his Washington associate Raymond Jones requesting Jones to interview the Examiner with regard to said application Serial No. 270,865, said letter containing the following statement:

"I am particularly anxious to receive the notice of allowance and to pay the final fee in this case at the earliest possible moment and I would appreciate your finding out from Examiner Justice in Division 5 how soon I may expect a formal notice of allowance, and if there is anything we can do to speed this up, I will be glad to do so."

That the Patent Office mailed the formal notice of allowance of this application from Washington on September 14, 1939 and on Septembr 15, 1939 Raymond Jones mailed to Mattingly the letter reading as follows:

"Last Wednesday, I had the Assignment Division make special its check on th title of this case.

"The notice of allowance was mailed on September 14 and I paid the final fee that day—Thursday, an issue day.

"You may remit this $30.00 as a separate item."

That this final fee was paid by Raymond Jones before Mattingly received the information that the application had been formally allowed.

That it had never been the practice of Raymond Jones to pay a final fee in any application for which he acted as associate for Mattingly unless Mattingly gave Jones specific instructions for Jones to pay such fee. It was not the intention of Mattingly by the letter of August 23, 1939 to Raymond Jones that Jones should pay this fee but only

that Jones expedite the issuance of the formal notice of allowance and Jones interpreted the letter as instructions for him to pay the final fee, contrary to the intentions of Mattingly.

That the first notification received by Mattingly that the notice of allowance had been entered in this case was received by Mattingly after Jones had paid the fee.

That on September 18, 1939 Mattingly wired Jones as follows:

> "Conditions Suddenly Changed Can You Withdraw Final Fee Walker Case"

That on September 20, 1939 Jones mailed a letter to Mattingly as follows:

> "In reply to your wire sent September 18, this Walker case had the number applied to the drawing last week-end and the file was sent to the printer on Monday. Regardless of these facts, no final fee can be withdrawn after the case is given a patent number.
>
> "Our only remedy, if necessary, is to abandon and re-file. If this is done, the Office should be advised as soon as possible as we did in the parent case.
>
> "I assumed from your letter of August 23 that speed was essential to secure early issue, hence paid the final fee with this in view."

That on September 22, 1939 Mattingly sent to Jones a letter reading as follows:

> "I am enclosing herewith the original of a continuing application which I have prepared

to take the place of the Walker application Serial No. 270,865, together with a statement of abandonment of that application.

"Will you please see that these are filed in the correct order so that the Walker application Serial No. 270,865 will not issue as a patent.

"I hope we won't have to do this again."

That the application referred to in said letter filed to take the place of application Serial No. 270,865 was filed in the Patent Office by Jones on September 25, 1939 and was given Serial No. 296,781, which application Serial No. 296,781 matured into patent No. 2,209,944, one of the patents here in suit.

That the two applications Serial Nos. 270,865 and 296,781 were directed to the same invention. The specification and drawings of application Serial No. 296,781 were the same as the specification and drawings of application Serial No. 270,865 with the exception of the insertion on Page 1 of the statement beginning in Line 11 as follows:

"and a continuation of my application Serial No. 270,865, filed April 29, 1939";

and on Page 2, Line 17, the word "fluid" was changed to read "liquid".

That the wording of Claims 2 and 3 of application Serial No. 270,865 was modified in the correspondingly numbered claims in application Serial No. 296,781 as follows:

Serial No. 270,865:

2. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating an acoustical impulse in the annular space between the tubing and the well casing to produce echoes from portions of the tubing string distinguishable from each other and from the echo from the unknown obstruction, observing the lapse of time between the creation of the impulse and arrival at a pre-determined point of the echoes from successive portions of the tubing string to thereby determine the velocity of the pressure wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

3. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating an acoustical impulse in the annular space between the tubing and the well casing of such magnitude as compared with the depth of the well and the resistance to pressure wave transmission therethrough as will produce echoes from portions of the tubing string distinguishable from each other and from the echo from the unknown obstruction, observing the lapse of time between the creation of the impulse and arrival at a predetermined point of the echoes from successive portions of the tubing

string to thereby determine the velocity of the pressure wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

Serial No. 296,781:

2. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating an acoustical impulse in the annular space between the tubing and the well casing to produce echoes from portions of the tubing string distinguishable from each other and from the echo from the unknown obstruction, observing the lapse of time between the arrival at a predetermined point of the echoes from successive portions of the tubing string to thereby determine the velocity of the pressure wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

3. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating an acoustical impulse in the annular space between the tubing and the well casing of such magnitude as compared with the depth of the well and the resistance to pressure wave transmission therethrough as will produce echoes from portions of the tubing

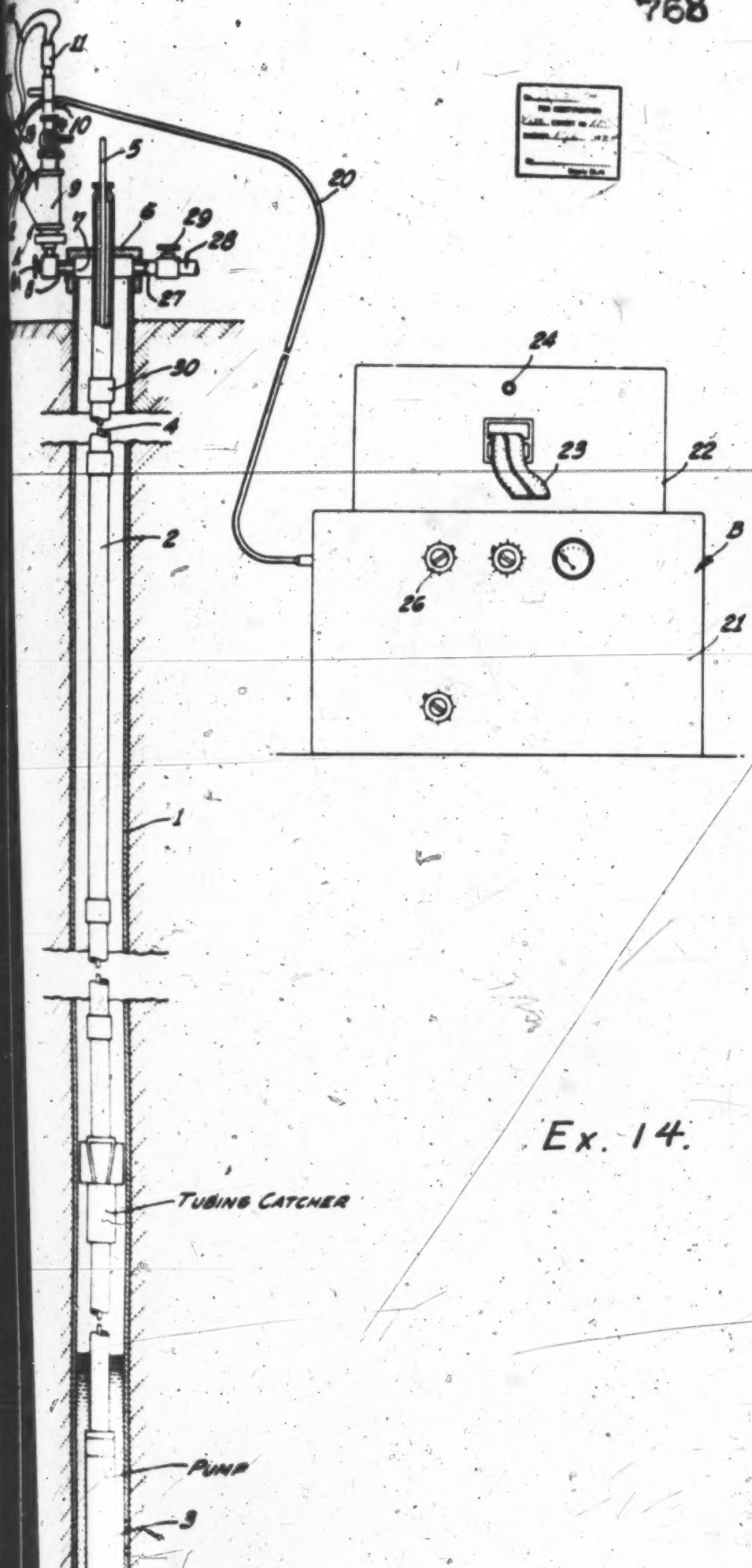
string distinguishable from each other and from the echo from the unknown obstruction, observing the lapse of time between the arrival at a predetermined point of the echoes from successive portions of the tubing string to thereby determine the velocity of the pressure wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

That Claims numbered 1, 4, 5, 6 and 7 of each of said applications are identical.

HAROLD W. MATTINGLY,
ROBERT W. FULWIDER,
Attorneys for the Plaintiffs.
FRANK L. A. GRAHAM,
EARL BABCOCK,
Attorneys for the Defendant.

Los Angeles, California, October 3, 1942.

[Endorsed]: Filed Oct. 6, 1942.

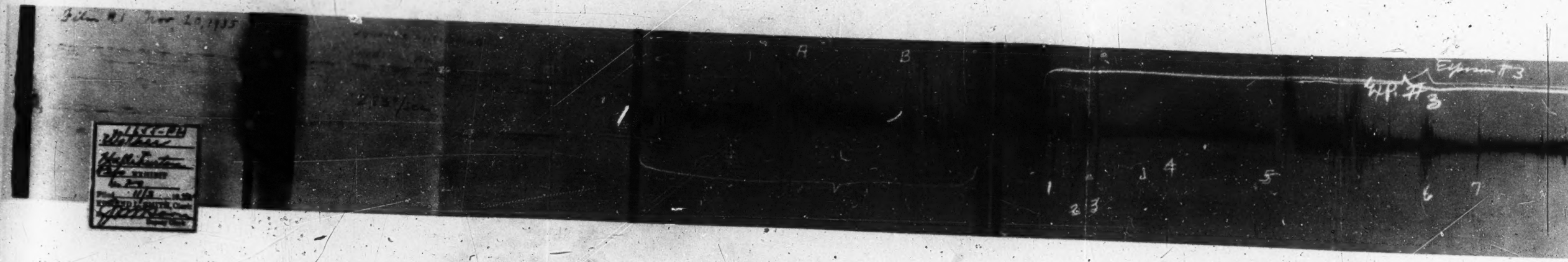

11
10
5
9
7
6
29
28
27
20
24
30
4
23
22
2
B
26
21
1
TUBING CATCHER
PUMP
3

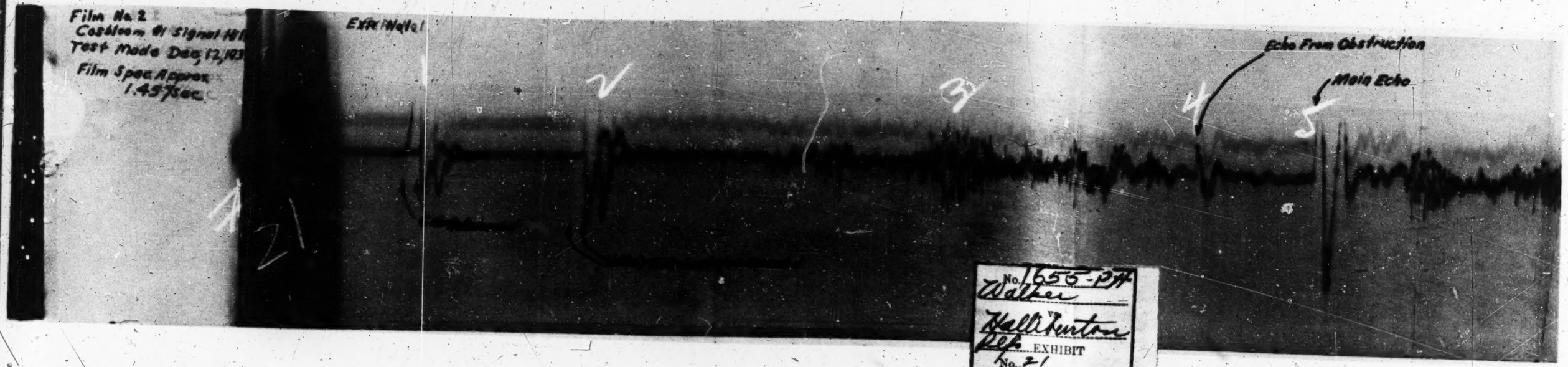
Ex. 14.

PLAINTIFFS' EXHIBIT No. 18

[Printer's Note: Plaintiffs' Exhibit No. 18 is reproduced following Defendant's Exhibit O-9 in this Book of Exhibits.]

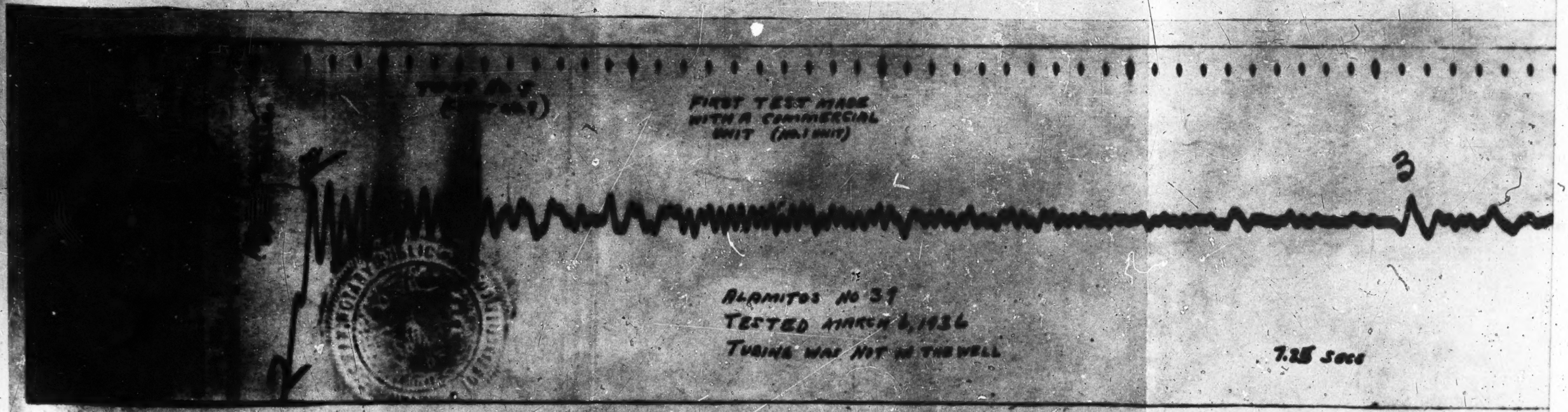
[redacted]

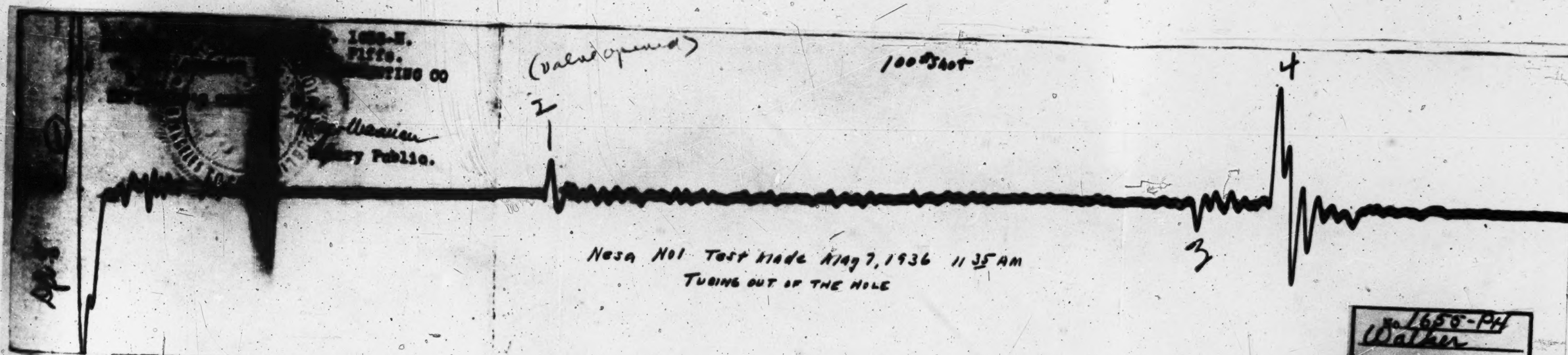

Film #1 Nov 20, 1935
A
B
Exposure #3
Exp. #3
1
2
3
4
5
6
7



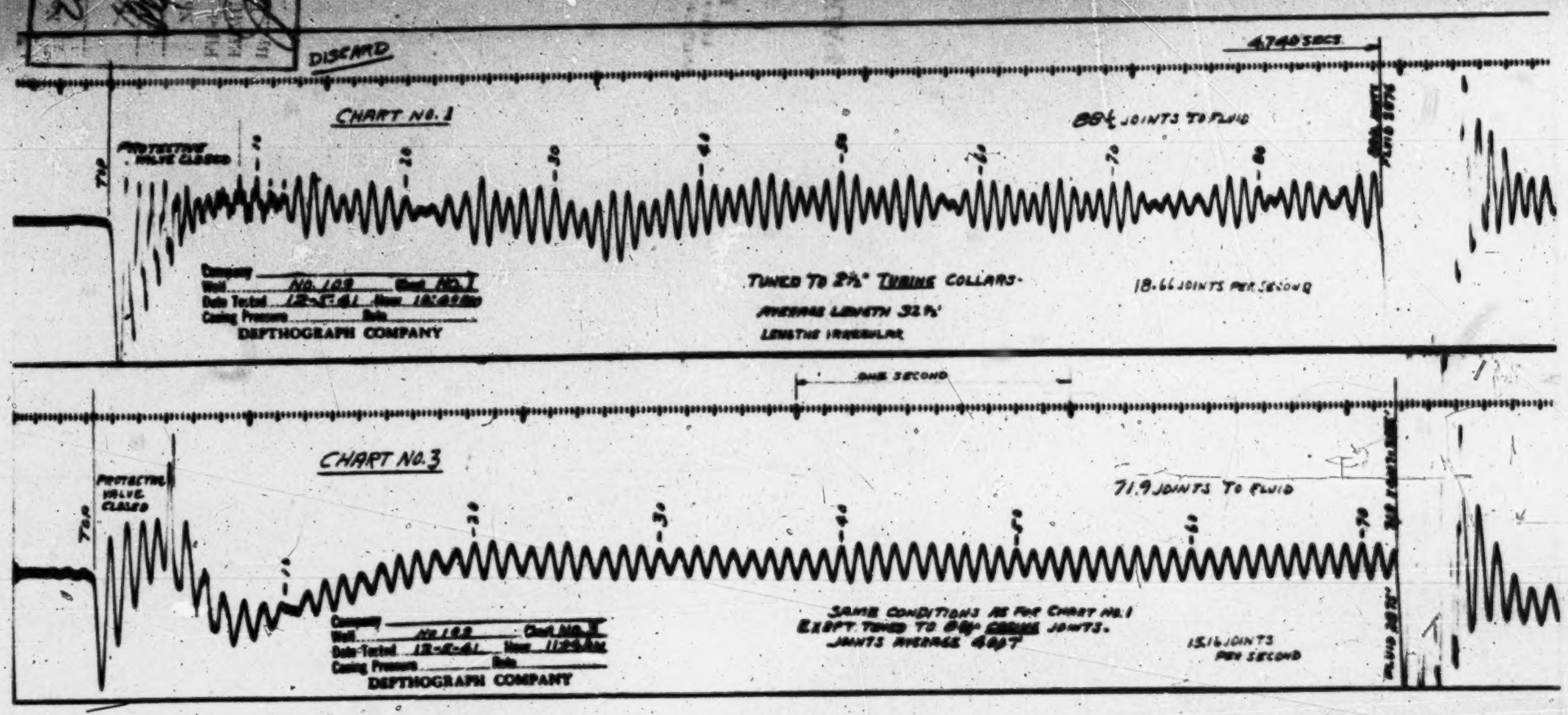
No. 1655-PH
Walker
vs.
Halliburton
Defs. EXHIBIT
No. 21
Filed 11/3 1942
EDMUND L. SMITH, Clerk
By [signature]
Deputy Clerk

BORE
MID
FIRE

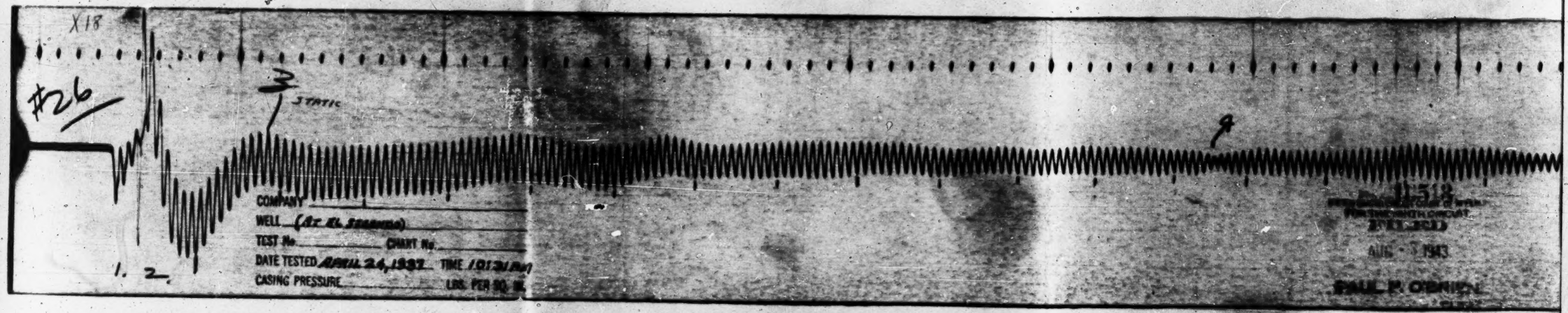

FIRST TEST MADE
WITH A COMMERCIAL
UNIT (NO. 1 UNIT)
3
ALAMITOS No 31
TESTED MARCH 6, 1936
TUBING WAS NOT IN THE WELL
7.25 SECS



No. 1655-PH
Walker
Halliburton
Plfs. EXHIBIT
No. 24
Filed 11/3 1942
EDMUND L. SMITH, Clerk
By
Deputy Clerk

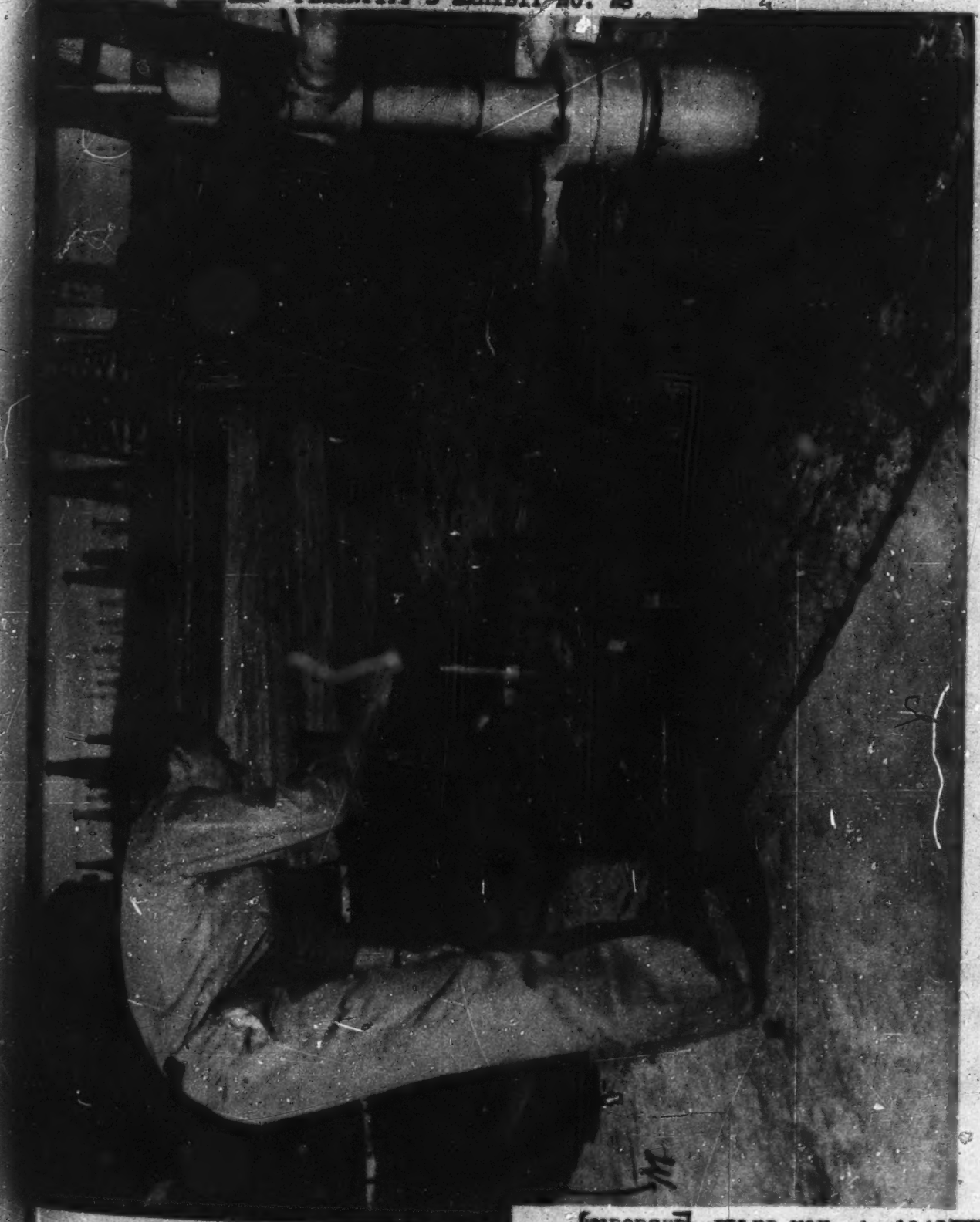

DISCARD
4.740 SECS
CHART NO. 1
88½ JOINTS TO FLUID
TOP
PROTECTIVE VALVE CLOSED
10
20
30
40
50
60
70
80
Company
Well NO. 109 Chart NO. 1
Date Tested 12-5-41 Hour
Casing Pressure Rate
DEPTHOGRAPH COMPANY
TUNED TO 2½" TUBING COLLARS.
AVERAGE LENGTH 32½'
LENGTHS IRREGULAR
18.66 JOINTS PER SECOND
ONE SECOND
CHART NO. 3
71.9 JOINTS TO FLUID
TOP
PROTECTIVE VALVE CLOSED
10
20
30
40
50
60
70
Company
Well NO. 109 Chart NO. 3
Date Tested 12-5-41 Hour
Casing Pressure Rate
DEPTHOGRAPH COMPANY
SAME CONDITIONS AS FOR CHART NO. 1
EXEPT TUNED TO 8⅝" CASING JOINTS.
JOINTS AVERAGE 40 FT
15.16 JOINTS PER SECOND

222

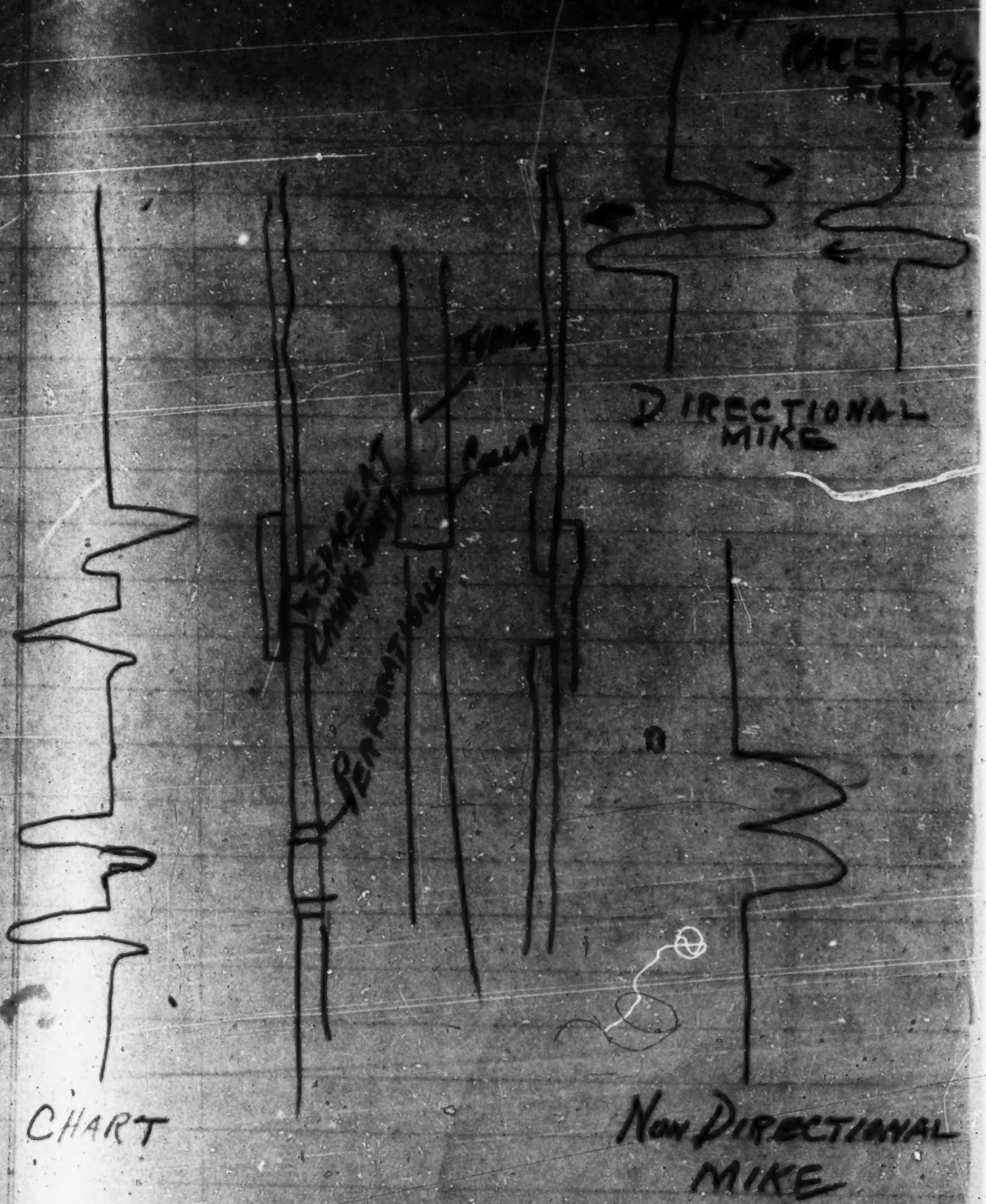

X18
#26
3
STATIC
9
1. 2.
COMPANY
WELL (AT EL SEGUNDO)
TEST No.
CHART No.
DATE TESTED APRIL 24, 1937
TIME 10:31 AM
CASING PRESSURE
LBS. PER SQ. IN.
11518
AUG - 3 1943
PAUL P. O'BRIEN

FILED NOV. 4, 1942
PLAINTIFF'S EXHIBIT NO. 27

PLAINTIFF'S EXHIBIT NO. 23



[ENDORSED] FILED NOV. 4, 1942



No. 1658-PH
Walker
vs.
Halliburton
Plf. EXHIBIT
No. 24
Filed 11/8 19 83
EDMUND L. SMITH, Clerk
By [signature]
Deputy Clerk

No. 10,518
UNITED STATES CIRCUIT COURT OF APPEALS
FOR THE NINTH CIRCUIT
FILED
AUG - 3 1943

CLERK'S COPY.

Vol. IV

TRANSCRIPT OF RECORD

(Pages 783 to 1140)

Supreme Court of the United States

OCTOBER TERM, 1943

No. 24

HALLIBURTON OIL WELL CEMENTING COMPANY, PETITIONER,

vs.

CRANFORD P. WALKER AND CRANFORD P. WALKER, D. A. WALKER, ET AL., DOING BUSINESS AS DEPTHOGRAPH COMPANY, COPARTNERSHIP

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT

PETITION FOR CERTIORARI FILED AUGUST 2, 1943.

CERTIORARI GRANTED OCTOBER 18, 1943.

Office - Supreme Court, U. S.
FILED
AUG 2 1945
CHARLES ELMORE CROPLEY
CLERK

TRANSCRIPT OF RECORD
IN SIX VOLUMES

IN THE

Supreme Court of the United States

October Term, 1945

No. 290

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Petitioner,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Respondents.

VOLUME IV

Book of Exhibits
(Defendant's Exhibits—Part I)

Pages 783 to 1140

UPON PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT

Rotary Colorprint, 661 Howard Street, San Francisco

No. 10513

United States
Circuit Court of Appeals
For the Ninth Circuit.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Appellant,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Appellees.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Appellants,

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Appellee.

Transcript of Record
In Five Volumes

VOLUME IV
Book of Exhibits
(Defendant's Exhibits—Part I)
Pages 783 to 1140

Upon Appeals from the District Court of the United States for the Southern District of California, Central Division

Rotary Colorprint, 590 Folsom St., San Francisco

DEFENDANT'S EXHIBIT A

390

Department of Commerce
United States Patent Office

To all persons to whom these presents shall come, Greetings:

This Is To Certify that the annexed is a true copy from the records of this office of the File Wrapper and Contents, in the matter of the

Abandoned Application of
Cranford P. Walker,

Filed April 29, 1939, Serial Number 270,865

for

Improvement in Method of Measuring Location of Obstructions in Deep Wells.

In Testimony Whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this fourth day of November, in the year of our Lord one thousand nine hundred and forty-one and of the Independence of the United States of America the one hundred and sixty-sixth.

[Seal] CONWAY P. COE
Commissioner of Patents.

Attest:

D. E. WILSON
Chief of Division.

2/150

784

NUMBER (Series of 1935)

270865

PATENT No.

1939

DATED

DIV. 5

(EX'R'S BOOK) 176

Name CRANFORD P. WALKER

ABANDONED

2175982

Oct. 10/39

of SAN MARINO

State of CALIFORNIA

Invention

METHOD OF MEASURING LOCATION OF OBSTRUCTIONS IN DEEP WELLS

ORIGINAL

APPLICATION FILED COMPLETE APR 29, 1939

Petition, Specification, Oath, First Fee $30, APR 29, 1939

1 sheets Drawings,

Drawing transferred to new office

Ser. No. 256781

RENEWED

This application referred to in Patent No. 2209944

Do not destroy. (See order No. 3166, 400 O.G. 1)

DO NOT DETACH

Examined and passed for Issue Sept. 14, 1939

L. W. Johnston Actg. Exr. Div. 5

Notice of Allowance

ABANDONED

Final Fee $30 Sept 14, 1939

Reexam'd and passed for Issue

Notice of Allowance

Final Fee

Attorney HAROLD W. MATTINGLY 720 PACIFIC FINANCE BLDG 621 SOUTH

LOS ANGELES CALIF

Associate Attorney Raymond Jones - 1427 - Eye St. N.W. City

No. of Claims Allowed 7 Print Claims 1 in O.G. Class

Title as allowed Method of measuring location of obstructions in Deep Wells

Division of App. No. 142699, Filed Sept. 7, 1937, Patent No. 2,156,519 May 9, 1939

Defendant's Exhibit A—(Continued)

Apr 29 - 39 219751 D—Check—30.00

Walter P. Huntley MAdison 1137

Harold W. Mattingly
Attorney at Law
Patent and Trademark Causes
621 South Hope Street
Los Angeles, California
2/150

April 25, 1939

Received May 6 1939 Division 5 Paper No.
Mail Division Apr 29 1939 U. S. Patent Office

Hon. Commissioner of Patents
Washington, D. C.

Sir;

Attached is application for Letters Patent of the United States, executed April 14, 1939, by Cranford P. Walker for Method Of Measuring Location Of Obstructions In Deep Wells; also attached is my check No. 1200 in the amount of $30.00 to cover the Government filing fee. (7 claims)

Respectfully,
HAROLD W. MATTINGLY

MM

PETITION

Received May 6 1939 Division 5, Paper No.
Received Oct 4 1939 Division 5, Paper No. 270865.
Mail Division Apr 29 1939 U. S. Patent Office

Defendant's Exhibit A—(Continued)

To the Commissioner of Patents:

Your petitioner, Cranford P. Walker, citizen of the United States, residing at San Marino in the County of Los Angeles, and the State of California, whose post office address is 2824 Carlaris Road San Marino, California, prays that Letters Patent may be granted ot him for the Method Of Measuring Location Of Obstructions In Deep Wells set forth in the annexed specification, and he hereby appoints

Harold W. Mattingly
720 Pacific Finance Building
621 South Hope Street
Los Angeles, California
(Registry No. 12,385)

his attorney, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.

(Sign here first name in full)

CRANFORD P. WALKER

SPECIFICATION

To All Whom It May Concern:

Be It Known, That I, Cranford P. Walker, a citizen of the United States residing at San Marino in the County of Los Angeles and State of California have invented certain new and useful improvements in Method Of Measuring Location

Defendant's Exhibit A—(Continued)

Of Obstructions In Deep Wells of which the following is a specification:

My invention relates to a method of measuring the location of obstructions in deep wells such as oil wells and has particular reference to methods for determining the location below the ground surface of the liquid level in the well, or the location of tools, pipe sections, couplings or other devices which constrict the well bore.

This is a division of my copending application Serial No. 162699, filed September 7, 1937, which has issued as United States Letters Patent No. 2,156,519 on May 2, 1939, wherein is described and claimed apparatus for measuring the location of obstructions and means for producing pressure wave echoes in which the echoes from certain of the obstructions are accented so as to make them more readily distinguishable.

During the active life of an oil well it is desirable from time to time to determine the location of the fluid level within the well for the purpose of determining the type of pumping apparatus most desirable to be used, determining the rate of flow of oil into the well, and for making other determinations desirable in the most efficient operation of the well.

Prior methods of determining the location of the fluid level or the location of other obstructions in the well have been generally of two types, one in which measuring apparatus has been lowered from

Defendant's Exhibit A—(Continued)

the ground surface to determine by the length of cable or the line extended into the well the depth or location of the fluid or other obstructions encountered by the instrument as it is lowered. Among devices to be lowered into the well is also included a pressure recorder which may be lowered into the well on a wire, the length of which is metered to determine the static pressure in the well at different levels, a variation of which includes a pressure recorder with a clock driven chart lowered on the bottom of the pump to obtain a record of the operating pressures or levels of the fluid. A further variation is that of lowering a bailer upon a rope and either measuring the wetted surface of the rope or repeatedly lowering the bailer until it brings up fluid, measuring the length of the line upon such occurrence. The other method is that of producing sound waves in the well and noting the elapsed time between the introduction of the sound and its return as an echo from the surface of the fluid or other obstruction encountered.

Neither of these methods is satisfactory, the first having the disadvantage of requiring the removal of oil flow tubing, sucker rods and other apparatus normally disposed in the well prior to the time the instrument is inserted in and lowered into the well, requiring a considerable length of time both for the removal of such apparatus, the reinsertion of the apparatus, and the making of the actual measurement. The other method is unsatisfactory primarily because of the relatively low intensity or

Defendant's Exhibit A—(Continued)

energy which can be employed in the sound wave so that the echo received back is of such low energy as to prevent its accurate detection and, further, little or no distinction is made by reason of such low energy between various types of obstructions encountered by sound wave.

A third method, namely, that of introducing a shock of relatively high intensity into the well, creating thereby a pressure wave which travels through the well, and measuring the elapsed time between the introduction thereof and the echo thereof, to give an indication of the depth of the fluid level and other obstructions, has been introduced, a relatively loud noise such as a shot or one form being that of creating an explosion in the well, another form being illustrated and described in United States Letters Patent No. 2,047,974, issued to Harold J. Wyatt and Paul E. Lehr on July 21, 1936. This latter method has the desirable characteristic of permitting the employment of relatively high intensity in the wave or impulse produced in the well and it is an object of my invention to improve upon the method disclosed in that patent and to eliminate or materially reduce factors of error encountered in the employment of that method.

Another object of my invention is to provide a method for measuring the location of fluid level or other obstructions in well bores, in which the intensity of the pressure impulse introduced into the well may be varied to compensate for well depth

Defendant's Exhibit A—(Continued)

and the character of the gaseous media through which the wave must travel to produce an echo of sufficient intensity to permit the same to be readily detected and translated.

Another object of my invention is to provide a method as set forth in the preceding paragraph wherein the pressure impulse may be so varied as to allow the detection and the separate determination of the location of a plurality of obstructions which may be encountered in the well.

Another object of my invention is to provide a method for the measurement of the location of fluid level or other obstructions in a well bore in which the pressure impulse introduced into the well produces an indication both of the fluid level and of the location of other obstructions in the well bore.

Another object of my invention is to provide a method of the character set forth in the preceding paragraph wherein the same pressure impulse introduced into the well to measure the fluid level or the location of other obstructions is employed to determine the velocity of the wave in the particular media encountered in the well.

Another object of my invention is to provide a method as set forth in the preceding paragraph wherein, knowing the location of one or more obstructions, tools or other devices in the well bore, the velocity of the wave within the well bore may be accurately determined from echoes produced thereby and enabling an operator to determine the unknown location of the fluid level by the mere

Defendant's Exhibit A—(Continued)

measure of the elapsed time between the introduction of the impulse into the well and the reception of a distinguishable echo from the fluid level, without necessitating introduction of corrective factors or other separate measurement of and determination of the character of the media in the well.

Another object of my invention is to provide a method for determining the location of fluid levels in well bores in which the location of and the number of tubing sections in the well may be determined by the same pressure wave created to measure the depth or the location of the fluid level.

Other objects of my invention will be apparent from a study of the following specifications, read in connection with the accompanying drawings, wherein:

Fig. 1 is a diagrammatic view illustrating a typical well cross section and the location and character of the apparatus required for determining the fluid level or location of other obstructions in the well in accordance with my method;

Fig. 2 is a diagrammatic view illustrating the type of record or indication which may be made with my method in its simplest application;

Fig. 3 is a diagrammatic view similar to Fig. 2 and illustrating the type of record or indication which may be made with my method but in which echoes produced by intermediate obstructions are not amplified; and

Fig. 4 is a diagrammatic view similar to Figs. 2 and 3 and illustrating the type of record or indi-

Defendant's Exhibit A—(Continued)

cation which may be made with my method, including the amplification of echoes from intermediate obstructions.

The method disclosed in United States Letters Patent issued to Wyatt and Lehr, hereinbefore referred to, is briefly that of introducing into a well bore a pressure impulse, either positive or negative, which may have any desired frequency as by the introduction into the well of a quantity of gas of known pressure and volume, the introduction of this impulse into the well producing a wave which will travel down the well until it encounters the fluid surface in the well and then the wave will be reflected and will travel back up the well to the ground surface where the echo or return wave may be detected, the measurement of the elapsed time between the production of the impulse and the arrival at the ground surface of the echo constituting a metsure of the location of the fluid level by the simple calculation of the elapsed time multiplied by the rate of travel or the velocity of the wave in the well. In making such calculations, it is correctly assumed that ~~the velocity of~~ the wave will act like an acoustical wave and its velocity will be the same as that of a sound wave. In air at normal temperatures and approximately sea level pressures, this rate would be 1100 feet per second but the gaseous content or media in the well is ordinarily not the same as air and correction must be made for the density, temperature or other

Defendant's Exhibit A—(Continued)

characteristics of the particular media encountered in the well, it being well known that the higher the temperature or the lower the density of the gaseous media through which the impulse travels, the greater the velocity of the wave.

In employing the method as set forth in the said patent, an approximation of the fluid level may be readily determined and this approximation or measurement may be determined in a relatively short length of time, without requiring the removal or disturbance of any of the apparatus contained within the well bore. However, to determine the fluid level with considerable accuracy, the rate of travel of the wave in the particular media encountered in any particular well must be known or must be determined since the density, temperature and character of the gaseous media in wells varies in each different oil field and in each individual well. I provide the pressure wave velocity in means for readily determining ~~at~~ any particular well, which may be arrived at as follows:

In Fig. 1, I have illustrated a typical oil well comprising the earth bore 1, usually lined with casing 2 or pipe of relatively large diameter, extending from the ground surface at 3 to the oil bearing sands at 4 where the casing is either perforated or is provided with a perforated liner through which the oil from the sands may enter to the interior of the casing. The casing is, of course, constructed of a plurality of lengths of pipe secured together by couplings or collars in any well known manner. A second pipe or string of pipes extend

Defendant's Exhibit A—(Continued)

down through the casing 2, this string of pipe being known as the oil flow tubing, indicated at 5, extending from the ground surface down to a position disposed below the level of the fluid in the well, which is indicated at 6, the lower end of the tubing string 5 having a pump 7 of any desired character located therein. Such pumps are usually operated by means of a string of sucker rods 8 which extend upwardly through the tubing string 5.

It is the common practice to employ in the tubing string 5 a tubing catcher 9 which may be of any of the well known constructions, the tubing catcher being usually located a relatively short distance above the level of the ^ pump ~~fluid~~ in the well so that should the tubing string break the tubing catcher 9 will grip the casing and prevent complete destruction of the tubing string. One or more of the tubing catchers 9 may be distributed throughout the length of the tubing string 5.

The tubing string 5 is constructed of a plurality of lengths of pipe coupled together by means of collars 10, which collars are usually of somewhat larger outside diameter than the outside diameter of the tubing from which the oil flow tubing is made.

Hence it will be noted that in the ordinary oil well there are a plurality of obstructions, each of which is capable of receiving and reflecting a sound wave or pressure wave passing down through the well, these obstructions including the fluid sur-

Defendant's Exhibit A—(Continued)

face 6, the tubing catcher 9 and each of the collars 10 of the tubing string.

In most wells the length of the tubing string between the ground surface 3 and the pump 4 is known, that is, records are usually kept showing the length of ∧ ~~each~~ such tubing string section and the number of each sections located within any given well. Particularly, records are usually kept as to the location along the tubing string of the catcher 9 so that by referring to these records an absolute calculation or determination of the distance between the ground surface and the tubing catcher or liner top is known. Hence to determine the location of the fluid level 6, it is only necessary to produce in the well a pressure impulse which will create the low frequency wave, and then translate the echoes received from the well in terms of echo impulses received from the tubing catcher or liner top and from the liquid surface. By comparing the time lapse between the production of the pressure impulse and the receipt of the echo from the tubing catcher with the time lapse between the creation of the pressure impulse and the receipt of the echo from the fluid surface, a positive and accurate measurement of the location of the fluid level may be obtained. That is, if the known location of the tubing catcher is 5000 feet below the ∧ ground surface and ~~fluid~~ it is desired to know the height of the fluid in the well, all that is necessary is to produce a pressure impulse, note or record the echo from the

Defendant's Exhibit A—(Continued)

tubing catcher, and note or record the echo received from the fluid surface.

The time lapse between the creation of the pressure impulse and the receipt of the echo from the tubing catcher denotes the velocity of the pressure wave in the particular media encountered in that particular well so that by measuring the additional elapsed time between the receipt of the echo from the tubing catcher and the receipt of the echo from the fluid surface, an accurate measurement may be obtained and no compensation need be made for possible errors due to different velocities of waves in different media because the mean velocity of the wave from the ground surface to the tubing catcher and return is the same as the mean velocity of the wave from the ground surface to the fluid surface and return.

The only item which must be provided for is that of producing a pressure wave echo of such magnitude and of such character that the echo from the tubing catcher can be distinguished from the echo received from the fluid surface.

As illustrated in Fig. 1, this distinction may be readily made by providing a suitable source of fluid pressure indicated at 11 which may be a tank, compressor or other source of fluid pressure at any desired value. It follows, of course, that the pressure impulse which must be produced in the well must be at a greater pressure than the pressure of gases in the well so that the pressure source 11 must be capable of delivering a pressure impulse

Defendant's Exhibit A—(Continued)

having a considerable differential over the static pressure of gases in the well or flowing therefrom. For example, if the well gases at the surface of the well are at a pressure of 500 pounds per square inch, the source of fluid pressure 11 must be capable of delivering, say, 600 pounds per square inch or more in order to create a pressure impulse of, for example, 100 pounds pressure differential.

The pressure source 11 is illustrated as being coupled to a pressure chamber 12, one end of which is connected as by means of tube 13 and valve 14 to the pressure source 11, while the opposite end of the pressure chamber 12 is connected by means of a nipple 15, a quick opening valve 16 and a nipple 17 to a length of pipe 18 which is in turn coupled as indicated at 19 to the well casing 2. The pressure chamber 12 is preferably provided with a suitable indicating pressure gage 20 by which the pressure within the pressure chamber 12 may be readily measured. Thus for the production of the pressure wave all that is necessary is to close valve 16, open valve 14 and allow pressure to be built up in the pressure chamber 12 to the desired pressure value, say, 600 pounds per square inch. Then the valve 14 is closed and valve 16 opened, allowing an impulse of 600 pounds per square inch to be injected into the well casing (the static pressure in which is, for example, 500 pounds per square inch).

A receiving device for receiving and registering the echoes of the pressure impulse from the various

Defendant's Exhibit A—(Continued)

obstructions within the well is illustrated as including the pipe 18 and pressure responsive device coupled thereto through a valve 21 to a diaphragm chamber 22, permitting a flexible diaphragm 23 to be placed into communication with the casing 2 whenever the valve 21 is opened. To control the sensitivity of response of the diaphragm 23 and in order to prevent undue distortion of the diaphragm 23 by the static pressure in the well and to avoid damage which would result therefrom, I prefer to allow the static pressure in the well casing 2 and pipe 18 to be equalized on both sides of the diaphragm 23 as by providing a by-pass 24 providing a restricted passage through which gas pressure in the chamber 22 on one side of the diaphragm may pass to the opposite side of the diaphragm, the filter 25 being interposed in the by-pass if desired to dry out the gas and prevent undue corrosion of the more delicate parts of the device contained in the diaphragm chamber 22. Attached to the diaphragm 23 is a mirror 26. In the front wall 34 of the diaphragm chamber 22 I mount a lens 35, through which light from a suitable light source 36 may pass into the chamber 22 to be reflected by the mirror 26, the reflected beam 37 passing back through the lens 35, as a ribbon beam which may be reflected or directed upon a ground glass screen 38 and upon a recording chart or strip of sensitized tape 39 to make a permanent record of the path described by the light beam 37. Suitable reflectors, such as indicated at 40, may be employed to direct the beam

Defendant's Exhibit A—(Continued)

in any desired direction while a reflector 40a may be interposed in a portion of the ribbon beam 37 to direct a portion thereof upon the screen 38, suitable condenser lenses 40b and 40c being interposed in the beam to draw the same to a point beam upon the screen 38 and tape 39.

Thus as the pressure within the casing 2 is varied as by the pressure wave resulting from the pressure impulse created within the casing 1, the mirror 26 will be moved, the amplitude of its movement representing the amplitude of the pressure variation. As the echo of the pressure impulse from any obstruction within the well is received upon the diaphragm 23, the mirror 26 will be moved in accordance with the amplitude of the echo impulse and will cause the echo impulses to be registered for observation, both by directing the light beam 37 upon the ground glass 38 where the amplitude of the echo may be visually observed and by directing the light beam 37 upon the recording tape 39, a permanent record of the pressure wave which is created within the casing 2 may be made and this wave or chart will show peaks of varying amplitude, each of which peaks represents an echo from a particular obstruction within the well, either the tubing collars 10, the tubing catcher 9 or the fluid surface 6.

The sensitized strip 39 may be arranged to be driven at any desired speed by means of a variable speed motor 41 coupled to a suitable source of

Defendant's Exhibit A—(Continued)

current 42 through a rheostat or other speed adjusting device 43 so that the tape or strip 39 may be driven at variable speeds.

By employing some device which will produce upon the record strip 39 a time lapse measurement, a direct comparison between the path described by the light beam and the lapse of time may be accomplished. I prefer to provide such mechanism including means for producing upon the strip 39 a series of dots or marks, each of which represents a fraction of a second, the line of dots, or marks extending substantially parallel to the general direction of the wave chart described by the light beam 37. This may be readily accomplished by providing a disc 44 having a plurality of openings 45 therein adapted to be rotated in the path of a secondary light beam 46 emanating from the light source 36. The light beam 46 passing through the openings of the disc 44 may be projected upon the same sensitized strip 39 to describe a series of marks thereon, one for each of the openings 45.

One of the openings 45a is preferably larger than the remainder so that upon each revolution of the disc 44 a distinguishing mark will be produced. Thus by providing ten openings 45, a series of marks 48a may be produced upon the record strip 39 representing ten equal divisions. The tenth mark being produced by the large opening 45a is of greater length or of greater size or in some other manner distinct from the remaining nine marks. By providing the disc 44 with any suit-

Defendant's Exhibit A—(Continued)

able time mechanism such as a synchronous motor 47, the marks produced upon the charts will represent lapse of time; for example, each mark representing 1/10th of a second while the space between the distinct marks will represent lapses of one second each.

Due to the fact that the depth of wells varies considerably and, further, due to the fact that conditions of obstruction or constriction of the space between the well casing 2 and the tubing string 5 varies considerably in different wells, the same pressure differential cannot be used successfully in all wells and it is necessary to vary the pressure impulse through considerably wide limits, dependent upon the conditions encountered at a particular well. For this reason I prefer to direct a portion of the beam 37 upon the ground glass screen 38 so that by firing one charge of gas pressure into the well and observing the path described by the light beam, a determination of whether or not the correct pressure impulse is being used may be made. For example, one pressure impulse which is estimated to be correct for a given well may not produce a sufficient fluctuation in the echo waves received from the tubing catcher and the fluid surface, and a higher pressure or greater quantity of gas must be used in order to create the desired impulse. Thus by observing the effect of a succession of pressure impulses liberated into the well, the person making the survey will be able to determine which of the echoes rebounds from the tubing catch-

Defendant's Exhibit A—(Continued)

er and which of the echoes rebounds from the fluid surface and thus determine when distinguishable echoes are being received from the different obstructions in the well.

The typical desired configuration of the path described by the light beam 37 is indicated in Fig. 2 where in "a" represents the path described by the light beam as a result of the pressure wave created by a discharge of gas from the chamber 12 into the well casing. From an inspection of the line a, it will be noted that this line is a relatively straight but somewhat wavy line, having distinct peaks at b, c and d. The peak b is that which will be produced by the deflection of the diaphragm 23 when the impulse of gas from the chamber 12 is liberated into the casing 2. At a predetermined time thereafter, dependent upon the velocity of the wave in the particular well, a peak c will be produced as a reflection from the tubing catcher 9, while at a predetermined time thereafter an additional peak or series of peaks will be produced at d as a reflection of the wave from the fluid surface.

Thus by observing the effects of a series of pressure impulses of different intensity or pressure, the operator may determine which impulse is most desirable to produce the distinctly recognizable and differentiatable peaks c and d, allowing him to differentiate between echo from the tubing catcher (or such other obstruction as may
be known to be in the well)
and the echo from the fluid surface. As herein-

Defendant's Exhibit A—(Continued)

before stated, knowing the depth or location of the tubing catcher 9, the comparison of the elapsed time between the peaks b and c and the elapsed time between the peaks b and d, an accurate determination of the fluid level may be produced.

magnitude of

After the most desirable ∧ pressure impulse has been determined, the motor 41 may be set into action and a permanent record of the path described by the light beam may be made upon the sensitized film 39 with assurance that the various peaks b, c and d will be readily distinguishable upon the diagram so produced.

As will be observed from an inspection of Fig. 2, the diagram on the strip 39 also shows the plurality of spaced dots or other means of indicating elapsed time, such series of dots being indicated at 48a.

Having made a diagram as indicated in Fig. 2, a direct measure and determination of the fluid depth may be achieved. Also it will be observed that by selecting impulses of the desired magnitude, reflections from other obstructions in the well may be noted and recorded, thus assisting in the location and determination of other restrictions as well as a mearurement of the fluid level.

For example, each of the collars 10 of the tubing string will produce a distinct echo differentiatable from the echoes from other sources. This allows the accurate measurement of the fluid level in a well where, by reason of failure to keep records or loss of records, the location of the tub-

Defendant's Exhibit A—(Continued)

ing catcher is not known or wherein the catcher is submerged or omitted. For example, in some wells tubing has been drawn out and replaced by other tubing and no record has been made of the lengths of tubing drawn out or the lengths of each section drawn out or the lengths or number of tubing sections employed to replace them so that to merely compare the time distance between the peaks b and c would not give a true indication of the velocity of the wave in the particular well. However, if it is reasonably assured that each of the tubing lengths is approximately the same, and the usual practice in oil wells is to employ tubing lengths in a given well, all of which are approximately the same, an indication of the number of tubing lengths located within any given well, multiplied by the average length of a tubing section, will give a true measure of the location of the tubing catcher or the location of the pump or other device which constitutes an obstruction in the well. For example, by selecting a desired pressure impulse, by comparison of a succession of pressure impulses and the waves produced thereby, upon the ground glass 38, a wave or line of the character indicated at a in Fig. 3 may be produced wherein, though a is still wavy, it is produced by a series of peaks e. By counting the number of these peaks, each of which represents a reflection back from a collar 10, the number of lengths of tubing between the peaks b, c and d may be determined.

Defendant's Exhibit A—(Continued)

However, in actual practice it is found that (^a[1]) ~~distortion of the annular space between the tubing and the casing, such as may be caused by perforations in the casing or distortion of the cross sectional shape of the tubing or casing or the formation of tubercules upon either of them,~~ will produce undesired echoes and will produce upon the record chart peaks which cannot readily be distinguished from those resulting from the echoes from the tubing collars, and I prefer therefore to provide some means which will be so tuned with the tubing collar echoes as to amplify or accent them and which will tend to dampen or filter out the undesired disturbance vibrations. As will be understood by those familiar with acoustics, if upon the multiplicity of sound waves emanating from the well as a result of the desired echoes and the disturbances there is superimposed another wave so tuned to the desired echo wave as to beat with it, the desired wave will be amplified and accented while the other or disturbance waves will tend to be damped out.

By selecting the correct length for the pipe 18, that is, by selecting the correct distance between the casing 2 and the diaphragm 23, a tuned wave may be produced which will ^ affect ~~effect~~ the movements of the diaphragm 23. Since it is desired to count the number of tubing collars, all that is necessary is to lengthen or shorten the pipe 18 until it is tuned to one of the harmonics of the impulses or echoes produced by the collars 10. From experience it has been found that selection of the pipe 18 of approximately

Defendant's Exhibit A—(Continued)

one-third of the length of a section or joint of the tubing 5, a third harmonic is produced which beats with the impulses echoed from the tube collars 10 to produce magnified or amplified peaks e and permits the ready distinguishing of the impulses produced by the collars 10 from other impulses.

I prefer, however, to employ in the length of the pipe 18 an adjustable coupling 19 which allows the accurate lengthening or shortening of the pipe 18 until, by observing the path of the light beam upon the ground glass 38, a distinct pattern is made represented by the line a on Fig. 4, in which each of the intermediate peaks e is amplified as indicated in Fig. 4 so that it is readily recognizable.

The adjustment of the coupling 19 should be made until, with a given pressure impulse, a uniform deflection of the mirror 26, that is, a uniform amplitude of the peaks e, is achieved, and by observing this upon the ground glass 38 the operator will note when the pipe 18 is of such length as to be "tuned" with the tubing lengths.

Thus, even though the location of the tubing catcher is not known, if the average length of tubing section is known, the production upon the strip 39 of a diagram such as shown in Fig. 4 allows the counting of each of the collars 10 and a clear understandable record is made of the length of tubing string between the impulses b, c and d, permitting the quick and accurate location and determination of the exact level of the fluid in the well.

Defendant's Exhibit A—(Continued)

As is described and claimed in my copending application Serial No. 270,866, filed April 29, 1939, an elongated tube or pipe 53 coupled as by means of a short pipe 54 to the pipe 18 and controlled by a valve 55 in such manner as to permit gas from the casing 1 to flow through the pipe or tube 53, thus providing in the pipe 53 an atmosphere corresponding to the atmosphere or gaseous medium in the casing 1. An open exhaust pipe 56 leads from the opposite end of pipe 53 open to the atmosphere or connected to a gas flow line so that the pressure within the pipe or tube 53 will remain substantially constant as of the value of the gas in the casing 1. Near one end of the tube 53, a diaphragm 57 may be provided and arranged to be vibrated at any desired frequency as by coupling the diaphragm ~~47~~ 57 by a pipe 58 open to the atmosphere at 58a, to a source of fluid pressure, such as compressed air, indicated at 59. A rotary valve 60 is interposed in the pipe 58 and arranged to be driven by means of a variable speed motor 61 regulated as to speed by ~~means of a variable speed motor 61 regulated as to speed by~~ means of a suitable rheostat or other controlling device 62 so that by rotating the motor 61 at any speed a series of pressure impulses will be created in the pipe 58, and will beat upon diaphragm 57 to create a pressure wave in the tube or pipe 53 of known frequency, the frequency being variable by varying the speed of motor 61.

At the opposite end of the pipe 53 I couple a

Defendant's Exhibit A—(Continued)

pressure responsive device which may be constructed in the same manner as the diaphragm chamber 22 and diaphragm 23 hereinbefore described. This pressure responsive device is illustrated at 63 coupled directly to the end of the pipe 53, the diaphragm 64 of which received the impulses transmitted through the pipe 53 to vibrate in response thereto and to move a mirror 65 in the same manner as was described with reference to the mirror 26. The mirror 65 reflects a light beam from a suitable source 66 upon a polygon of mirrors 67 revolved by means of an adjustable speed motor 67a at a speed synchronous with the speed of the motor 61 so that the amplitude and uniformity of the vibrations of the diaphragm 64 may be visibly observed.

As is well known in the art, each gaseous medium, variable as to density, temperature, etc., is resonant to pressure waves or sound waves of predetermined frequency. Thus by varying the speed of operation of the motor 61 until the pressure impulse created by the diaphragm 57 makes one round trip (or multiple thereof) to the diaphragm 64 and back to the diaphragm 57 in time to just synchronize with the next impulse created by the diaphragm 57, the pattern described by the beam of light on the mirrors 67 will show maximum amplitude, and noting the frequency of the impulses produced upon the diaphragm 57 (that is, noting the speed of the motor 61) the velocity of the sound through this particular gaseous me-

Defendant's Exhibit A—(Continued)

dium may be readily determined by comparing this frequency with the frequency at which a condition of perfect resonance is achieved at the pipe 53 with air in it.

It will therefore be observed that I have provided a method of determining the location of obstructions in wells and accurately locating and measuring the fluid level in a well without the necessity of removing any of the apparatus from the well, the entire measurement and determination being accomplished in a relatively short time.

It will be understood by those skilled in the art that the creation of pressure impulses within the well may be accomplished by decreasing the pressure in the well instead of admitting a charge of gas from the pressure chamber 12 into the well. For example, if the pressure in the well is relatively high, the valve 16 in the pressure chamber may be closed and the valve 14 opened, allowing the pressure in the chamber 12 to reduce to some value less than the casing head pressure of the well. Then by closing valve 14, and opening valve 16 a measured quantity of gas will rapidly discharge or surge into the chamber 12, creating a pressure impulse within the well which acts in the same manner as hereinbefore described for the introduction of pressure from the tank or other source 11.

It will also be understood that if desired special constructions may be placed in the well for future measurements of the fluid level therein to take the

Defendant's Exhibit A—(Continued)

place of the tubing catcher 9. Such constrictions could comprise a closed cylinder of pipe surrounding and attached to one of the tubing sections when the tubing is run into the well and by noting and recording the location of such constriction, the future measurements of the fluid level by my pressure impulse method can be readily determined, employing the reflection of the wave from the restricting member in place of the reflection from a tubing catcher 9 or other restriction in the well.

While I have shown and described the preferred embodiment of my invention, I do not desire to be limited to any of the details of construction shown and described herein, except as defined in the appended claims.

HWM:MM

I CLAIM:

1. The method of accurately determining the unknown location of an obstruction in a well having a string of tubing therein constructed of a plurality of lengths of tubing, each of approximately the same length and connected to each other by couplings, which consists in creating a pressure impulse in the annular space between the tubing and casing of the well, registering the echoes from the tubing collars and from said obstruction, and counting the tubing collar echoes occurring between the creation of the pressure impulse and the echo from the unknown obstruction, to determine the location of the unknown obstruction.

Defendant's Exhibit A—(Continued)

2. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating an acoustical impulse in the annular space between the tubing and the well casing to produce echoes from portions of the tubing string distinguishable from each other and from the echo from the unknown obstruction, observing the lapse of time between the creation of the impulse and arrival at a predetermined point of the echoes from successive portions of the tubing string to thereby determine the velocity of the pressure wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

3. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating an acoustical impulse in the annular space between the tubing and the well casing of such magnitude as compared with the depth of the well and the resistance to pressure wave transmission therethrough as will produce echoes from portions of the tubing string distinguishable from each other and from the echo from the unknown obstruction, observing the lapse of time between the creation of the impulse and arrival at a predetermined point of the echoes from successive portions of the tubing string to thereby determine the velocity of the pressure

Defendant's Exhibit A—(Continued)

wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

4. The method of determining the unknown location of an obstruction in a well having a casing with tubing therein restricting the volumn of the annular space within the casing and having another obstruction therein at a known location above the unknown obstruction, which consists in creating in the annular space an acoustical impulse to produce echoes from different obstructions distinguishable from each other, observing the lapse of time between the creation of the impulse and the arrival at a predetermined point of the echo from the known obstruction to thereby determine the velocity of the pressure wave in that particular well, and measuring the lapse of time between the creation of the impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

5. The method of determining the unknown location of an obstruction in a well having a casing with tubing therein restricting the volumn of the annular space within the casing and having another obstruction therein at a known location above the unknown obstruction, which consists in creating in the annular space an acoustical impulse of such magnitude as compared with the depth of the well and the resistance to pressure wave transmission therethrough as will produce echoes from different

Defendant's Exhibit A—(Continued)

obstructions distinguishable from each other, observing the lapse of time between the creation of the impulse and the arrival at a predetermined point of the echo from the known obstruction to thereby determine the velocity of the pressure wave in that particular well, and measuring the lapse of time between the creation of the impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

6. The method of determining the unknown location of an obstruction in a well, which consists in placing another obstruction in the well at a known depth in the well, creating a pressure impulse in the well, observing the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo thereof from the obstruction of known location, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

7. The method of determining the unknown location of an obstruction in a well having a casing with tubing therein restricting the volume of the annular space within the casing and having an approximately known depth and a known pressure of gas within said space, from which the approximate magnitude of acoustical impulse required to traverse the restricted space and produce echoes from the several obstructions in the well may be estimated, which consists in introducing into said

Defendant's Exhibit A—(Continued)

space between the casing and tubing a series of acoustical impulses, each of different magnitude approximating the estimated magnitude to produce from each impulse echoes from the different obstructions in the well, observing the echoes that are produced by each impulse to select the one that produces distinguishable echoes from each of the obstructions in the well, and recording the echoes of an impulse of the selected magnitude in the relative times and order in which they are received at the ground surface. [151]

In Testimony Whereof, I affix my Signature.

CRANFORD P. WALKER.

OATH

State of California
County of Los Angeles—ss

Cranford P. Walker, the above named petitioner, being duly sworn, deposes and says that he is a ctiizen of the United States, and resident of San Marino, in the County of Los Angeles, State of California, that he verily believes himself to be the original, first and sole inventor or discoverer of the Method of Measuring Location of Obstructions in Deep Wells, described and claimed in the annexed specifications; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery

Defendant's Exhibit A—(Continued)

thereof, or more than two years prior to the filing of his parent application for United States Letters Patent Serial No. 162,699, of which this application is a division, or in public use or on sale in the United States for more than two years prior to the said parent application; that said invention has not been patented in any country foreign to the United States on any application filed by him or his legal representatives or assigns more than twelve months prior to this application; and that no application for patent on said invention has been filed by him or his legal representatives or assigns in any country foreign to the United States.

CRANFORD P. WALKER

Subscribed and sworn to before me, this 14th day of April, 1939.

MARJORIE McKAY
Notary Public in and for the
County of Los Angeles,
State of California

My Commission Expires July 14, 1941

Defendant's Exhibit A—(Continued)

Mail Division Aug - 7 1939 U. S. Patent Office

Received Aug 8 1939 Division 5 Paper No. 4

Amendment A & Print.

In the United States Patent Office

Division 5 - Room 3077

Cranford P Walker

METHOD OF MEASURING LOCATION OF OBSTRUCTIONS IN DEEP WELLS

Filed April 29, 1939

Serial No. 270,865

Los Angeles, California

August 3, 1939

Hon. Commissioner of Patents

Washington, D. C.

Sir:

In response to the Office action of July 17, 1939, please amend the above identified application as follows:

Page 1, after the comma at the end of Line 5, insert—which has issued as United States Letters Patent No. 2,156,519 on May 2, 1939,—.

Page 3, Line 12, after "creating" insert—a relatively loud noise such as a shot or—.

Page 6, Line 24, cancel "the velocity of"; same line, after "wave" insert—will act like an acoustical wave and its velocity—.

Page 7, Line 19, cancel "at" and substitute—the pressure wave velocity in—.

Page 8, Line 15, change "fluid" to read—pump—.

Page 9, Line 8, change "each" to read—such—; Line 27, change "fluid" to read—ground—.

Defendant's Exhibit A—(Continued)

Page 13, Line 3, cancel "1"; Line 13, change "34" to read—37—.

Page 15, Line 25, before the period insert—and thus determine when distinguishable echoes are being received from the different obstructions in the well—.

Page 16, Line 18, after "catcher" insert—(or such other obstruction as may be known to be in the well)—; Line 25, after "desirable" insert—magnitude of—.

Page 17, Line 25, change "section" to read—sections—.

Page 18, Line 2, after "are" insert—approximately—; cancel from "distortion" in Line 18 to the comma in Line 22, and substitute—

A'

irregularities in the annular space between the tubing and the casing, such as may be caused by imperfect abutment of adjacent casing sections or the presence of tubercules upon either the casing or the tubing.—

Page 19, Line 4, change "effect" to read—affect—.

Page 20, Line 11, after "No." insert—270,866—; same line, after "filed" insert—April 29, 1939—; Line 25, change "47" to read—57—; cancel from "means" in Line 29 through "by" in Line 30.

REMARKS

In view of the allowance of all of the claims in this application, the entire specification has been

Defendant's Exhibit A—(Continued)

carefully reviewed and the foregoing formal corrections have been made.

In making this review it was noted that certain reference characters had been inadvertently omitted from the drawing and it is requested that the Examiner approve the addition of these reference characters as shown in red ink on the accompanying print so that these may be added to the drawing at the same time the drawings are corrected to overcome the criticism made by the Chief Draftsman.

As was explained to the Examiner in the personal interviews had with him in connection with the parent application of which this case is a division, the applicant is extremely anxious to issue this patent at the earliest possible moment and the Examiner's approval of the submitted corrections and early mailing of a noitce of allowance in this case will be sincerely appreciated.

Respectfully submitted,

HAROLD W. MATTINGLY,

Attorney for Applicant.

HWM:MM

181/0.5 4/ 1

RECEIVED

270865

MAY 6 1939

Division 5. Paper No. 21

982
10-10

Print of drawing as originally filed.

Fig. 1.

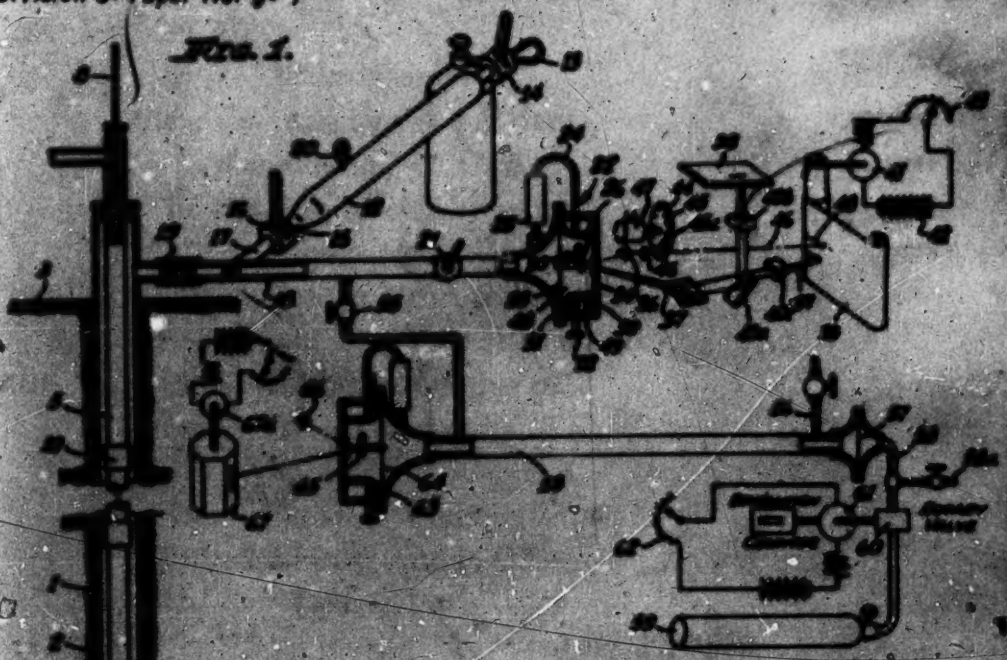


Fig. 2.

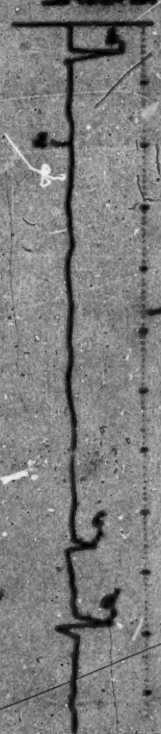


Fig. 3.

Fig. 4.

INVENTOR.
CRAWFORD R. WALKER

BY [signature]

ATTORNEY.

5

181-0.5

Defendant's Exhibit A—(Continued)

Div. 5 Room 3077

Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name

Paper No. 3

All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

260

Department of Commerce
United States Patent Office
Washington

LWJ/H July 17, 1939

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE
Commissioner of Patents,

Applicant: Cranford P. Walker
Ser. No. 270,865
Filed Apr. 29, 1939
For Method of Measuring Location of Obstructions in Deep Wells

Harold W. Mattingly
720 Pacific Finance Bldg.
621 South Hope St.
Los Angeles, Calif.

Mailed Jul 17 1939

The draftsman objects to the drawing accompanying this application in that the lines are pale

Defendant's Exhibit A—(Continued)

in parts. The present drawing may be corrected.

Page 20, second paragraph, reference to a co-pending application should be completed.

Claims 1 to 7 inclusive appear to contain allowable subject-matter as at present advised.

The prosecution of this case is closed except for the correction of formal matters. Ex parte Quayle, 453 O. G. 213.

C. W. ROBINSON,
Examiner.

L.W.J.

Mail Division Aug - 7 1939 U. S. Patent Office

2/150

Received Aug 8 1939 Division 5, Paper No. 4

Part of

In the United States Patent Office

Cranford P. Walker

Method of Measuring Location of Obstructions in Deep Wells

Filed April 29, 1939

Serial No. 270,865

Division 5 - Room 3077

Los Angeles, California
August 3, 1939

Account

Hon. Commissioner of Patents
Washington, D. C.

Attention: Chief Draftsman

Sir:

Please correct the drawings in the above entitled

Defendant's Exhibit A—(Continued)

application to avoid the criticisms of paleness of lines and also make the changes indicated in red ink in the accompanying print.

Please charge the cost of making these changes to my miscellaneous fees account.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant

Approved LWJ Div. 5.
Received in Div. C Aug 16 1939
Correction ordered Aug 19 1939 $1.00 Account.
Div. C corrected Aug 29 1939
Print returned by Drafting Div.
CN by Friday USPO R PV.
HWM:MM

Application Div. U. S. Patent Office Sep 1 '39
Received Sep 1 1939 Division 5, Paper No. 5
Assoc. Power of Attorney.

In the United States Patent Office

In re Application of
Cranford P. Walker
Serial No. 270,865
Filed April 29, 1939
Method of Measuring
Location . . . Wells

ASSOCIATE POWER OF ATTORNEY

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Please recognize Mr. Raymond Jones, of 1427 Eye

Defendant's Exhibit A—(Continued)

Street, N. W., Washington, D. C., as associate in the above entitled application.

HAROLD W. MATTINGLY
Attorney of Record

HWM:VM

Div. 5. 3077

TITLE REPORT

No. 270,865, a Div. of Ser. No. 162,699.

Name Cranford P. Walker.

The title appears from the assignment records to be vested in: The Inventor.

Examined up to and including Aug. 26, 1939.

This certificate dated Sept. 13, 1939.

H. C. SPIELMAN,
Asst. Chief of Assignment Division.

No further assignments appear to have been received for record including Sept. 9, 1939.

Defendant's Exhibit A—(Continued)

Mailed Sep 14 1939.

E—Div. 5

Address Only

The Commissioner of Patents

Washington, D. C.

Serial No. 270,865

181

Department of Commerce

United States Patent Office

Washington

Sept. Fourteen, 1939

Cranford P. Walker

Your Application for a patent for an Improvement in Method of Measuring Location of Obstructions in Weep Wells filed Apr. 29, 1939 has been examined and Allowed with 7 claims.

The final fee, Thirty Dollars, With $1 Additional For Each Claim Allowed in Excess of 20, must be paid not later than Six Months from the date of this present notice of allowance. If the final fee be not paid within that period, the patent will be withheld; See Revised Statutes, Section 4885 as Amended by Act of Congress Approved August 9, 1939.

The office delivers patents upon the day of their date, on which date their term begins to run. The preparation of the patent for final signing and sealing will require about four weeks, and such work will not be begun until after payment of the necessary final fee.

When the final fee is paid, there should also be

Defendant's Exhibit A—(Continued)

sent, Distinctly and Plainly Written, the name of the Inventor, Title of the Invention, and Serial Number as Above Given, Date of Allowance (which is the date of this circular), Date of Filing, and, if assigned, the Names of the Assignees.

If it is desired to have the patent issue to an Assignee or Assignees, an assignment containing a Request to that effect, together with the Fee for recording the same, must be filed in this office on or before the date of payment of the final fee.

After issue of the patent, uncertified copies of the drawings and specifications may be purchased at the price of Ten Cents Each. The money should accompany the order. Postage stamps will not be received.

The final fee will Not be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

Notice.—When the number of claims allowed is in excess of 20, no sum less than $30 plus $1 additional for each claim in excess of twenty can be accepted as the final fee.

Respectfully,

CONWAY P. COE

Commissioner of Patents.

This Application Cannot Be Renewed.

Raymond Jones
1427 Eye St. N. W.
Washington, D. C.

Defendant's Exhibit A—(Continued)

[Printed in Margin]: In remitting the final fee give the serial number at the head of this notice.

[Printed in Margin]: Uncertified checks will not be accepted.

Sep - 14 - 39 051533 B—Check—30.00
Mail Division Sep 14 1939 U. S. Patent Office
327

Final Fee Paid to the Commissioner of Patents
(Be careful to give correct Serial No.)

Serial No. 270865 Div. 5.
Inventor: Cranford P. Walker
Patent to be issued to Cranford P. Walker
Name of invention, as allowed: Meth. of Measuring Location of Obstructions in Deep Wells.
Date of payment: Sept 14 1939
Fee: $30
Date of filing: Apr 29 1939.
Date of circular of allowance: Sept. 14 1939

The Commissioner of Patents will please apply the accompanying fee as indicated above.

H. W. MATTINGLY
Attorney.

Send patent to
H. W. Mattingly
621 South Hope St.
Los Angeles, Calif.

Final fees will not be received from other than the applicant, his assignee or attorney, or a party in

Defendant's Exhibit A—(Continued)

interest as shown by the records of the Patent Office, Nor Will They Be Applied in Pending Applications.

In the United States Patent Office
Division 5—Room 3077

Mail Division Sep 25 1939 U. S. Patent Office
U. S. Patent Office Sep 25 1939 Issue Division.
Cranford P. Walker
Method of Measuring Location of Obstructions in Deep Wells
Filed April 29, 1939
Serial No. 270,865
2175982
Oct. 10

Los Angeles, California
September 22, 1939

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

I hereby abandon the above entitled application.

Respectfully submitted,
CRANFORD P. WALKER
Inventor

No further assigts H.C.S.

(Stamped)
ABANDONED
9/25/39m

Defendant's Exhibit A—(Continued)

Alfred M. Houghton 270865—6.
Counselor at Law
The Munsey Building

Washington, D. C.
September 14, 1940

Docket Division Sep 16 1940 U. S. Patent Office.

Honorable Commissioner of Patents,
Washington, D. C.

Sir:

re: Cranford P. Walker Patent 2,209,944
Issued July 30, 1940 for Method of
Measuring Location of Obstructions in
Deep Wells.

Kindly grant me permission and power to inspect application Serial No. 270,865, filed Apr. 29, 1939 by Cranford P. Walker, and of which the above patent is a continuation.

On the face of patent No. 2,209,944, application Serial No. 270,865 is mentioned and I find that in the perusal of the patent it will be necessary for me to see the parent application.

I am,
Respectfully,
A. M. HOUGHTON
wk

[Longhand Note]: Hold for Tuesday.
OK ELK 9/17/40 thru.

Defendant's Exhibit A—(Continued)

ABS

September 26, 1939

Mr. Cranford P. Walker,
Care Harold W. Mattingly,
720 Pacific Finance Building,
621 South Hope St.,
Los Angeles, California.

My dear Mr. Walker:

I have your letter of Abandonment in connection with your application filed April 29, 1939, for Method of Measuring Location of Obstructions in Deep Wells, Serial Number 270,865, allowed September 14, 1939.

The application has been marked Abandoned in accordance with your request.

Sincerely yours,

J. A. BREARLEY,
Chief Clerk.

L/Div/37

Defendant's Exhibit A—(Continued)

270865—7

Law Offices
Earle D. Crammond
Patent and Trade Mark Causes
Earle Building
Washington, D. C
District 9899

Docket Division Oct 15 1941 U. S. Patent Office.

October 13, 1941.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Permission is hereby requested for access to the file of the application of Cranford P. Walker, Serial No. 270,865, filed April 26, 1937. This application is referred to in patent 2,209,944, in the second paragraph of page 1. Patent 2,209,944 is involved in a suit in the Southern District of California, Civil Action 1655-H. It is necessary, in order to properly prepare the defense in the aforesaid law suit, for me to have access for the purpose of making copies of Serial No. 270,865.

Respectfully,
E. D. CRAMMOND.

EDC:I
OK. 10/15/41 A. F. Rohrman.

Defendant's Exhibit A—(Continued)

421

1939

Contents

1. Application. . . . . papers.
2. Print May 4/39
3. Letter July 17/39
4. Amendment A & Print Aug. 7/39
5. Assoc. Power of Attorney Sept. 1/39
6. Petition for Access Sept. 16, 1940
7. Petition for Access Oct. 15, 1941

[Endorsed]: Filed Oct. 7, 1942.

DEFENDANT'S EXHIBIT B

390*

Department of Commerce
United States Patent Office

To all persons to whom these presents shall come, Greeting:

This Is To Certify that the annexed is a true copy from the records of this office of the File Wrapper and Contents, in the matter of the

Letters Patent of
Cranford P. Walker,

Number 2,209,944 Granted July 30, 1940.

for

Improvement in Methods of Measuring Location of Obstructions in Deep Wells.

In Testimony Whereof I have hereunto set my hand and caused the seal of the Patent Office to be

Defendant's Exhibit B—(Continued)

affixed at the City of Washington this seventh day of November, in the year of our Lord one thousand nine hundred and forty-one and of the Independence of the United States of America the one hundred and sixty-sixth.

(Seal) CONWAY P. COE
Commissioner of Patents.

Attest:

D. E. WILSON
Chief of Division.

834

NUMBER (Series of 1936) 2/150

296781

PATENT No. 2209944

1939

DATED JUL 30 1940

DIV. 5

(EX'R'S BOOK) 183

Issue Jul 30/40

Name CRANFORD P. WALKER,

of SAN MARINO,

State of CALIFORNIA

Invention METHOD OF MEASURING LOCATION OF OBSTRUCTIONS IN DEEP WELLS

ORIGINAL	RENEWED
APPLICATION FILED COMPLETE SEPT 25, 1939	
Petition, Specification, Oath, First Fee $30, 1 sheets Drawings, SEPT 25, 1939	
Examined and passed for Issue Nov 1, 1939 C.W. Robinson Exr. Div. 5	Reexam'd and passed for Issue ____, 193 ____ Exr. Div. ____
Notice of Allowance Nov 1, 1939 By Commissioner.	Notice of Allowance ____, 193 By Commissioner.
Final Fee $30 May 1, 193	Final Fee ____, 193

Attorney HAROLD W. MATTINGLY 720 PACIFIC FINANCE BLDG 621 S. HOPE ST LOS ANGELES CALIF.

Associate Attorney Raymond Jones - 1[illegible] Eye U. N. W. City

No. of Claims Allowed 9 ~~8~~ Print Claims 1 in O.G. Class 1[illegible]-3.5

Title as allowed Method of measuring location of obstructions in Deep Water Wells

Division of App. No. 142,689 Filed Sept. 7, 1939, Filed Sept. 7, 1939, Filed Sept. 7, 1939

Defendant's Exhibit B—(Continued)

Walter P. Huntley MAdison 1137
Harold W. Mattingly
Attorney at Law
Patent and Trademark Causes
621 South Hope Street
Los Angeles, California
2/150
September 22, 1939

Mail Division Sep 25 1939 U. S. Patent Office.
Received Oct 4 1939 Paper No. A/E

Hon. Commissioner of Patents
Washington, D. C.

Sir:

Attached is application for Letters Patent of the United States executed September 22, 1939, by Cranford P. Walker for Method of Measuring Location of Obstructions in Deep Wells; also attached is my check no. 1446 in the amount of $30.00 to cover the Government filing fee (7 claims).

For drawings in connection with this application, it is requested that the Patent Office transfer the original drawings from application Serial No. 270,865 of which this is a continuation and it is further requested that photostatic prints of said drawings be furnished for application Serial No. 270,865,

Defendant's Exhibit B—(Continued)

the cost of which may be charged to my Miscellaneous Fees Account.

Respectfully,

HAROLD W. MATTINGLY

VM

Encls.

This case in issue of Oct 10/39
File available Sept 28
Drawing available Oct 6

PETITION

Mail Division Sep 25 1939 U. S. Patent Office
Received Oct 4 1939 Division 5, Paper No. 296781
Sep-25-39 058189 B - Check — 30.00

To the Commissioner of Patents:

Your petitioner, Cranford P. Walker, citizen of the United States, residing at San Marino in the County of Los Angeles and the State of California, whose post office address is 2824 Carlaris Road San Marino, California; prays that Letters Patent may be granted to him for the Method of Measuring Location of Obstructions in Deep Wells set forth in the annexed specification, and he hereby appoints

HAROLD W. MATTINGLY
720 ~~924~~ Pacific Finance Building
621 South Hope Street
Los Angeles, California
(Registry No. 12,385)

his attorney, with full power of substitution and

Defendant's Exhibit B—(Continued)

revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.

(Sign here first name in full)

CRANFORD P. WALKER

SPECIFICATION

To All Whom It May Concern:

Be it known, that I, Cranford P. Walker, a citizen of the United States residing at San Marino in the County of Los Angeles and State of California have invented certain new and useful improvements in Method of Measuring Location of Obstructions in Deep Wells of which the following is a specification:

My invention relates to a method of measuring the location of obstructions in deep wells such as oil wells and has particular reference to methods for determining the location below the ground surface of the liquid level in the well, or the location of tools, pipe sections, couplings or other devices which constrict the well bore.

This is a division of my copending application Serial No. 162,699, filed September 7, 1937, which has issued as United States Letters Patent No. 2,156,519 on May 2, 1939, and a continuation of my application Serial No. 270,865, filed April 29, 1939, wherein is described and claimed apparatus for measuring the location of obstructions and means

Defendant's Exhibit B—(Continued)

for producing pressure wave echoes in which the echoes from certain of the obstructions are accented so as to make them more readily distinguishable.

During the active life of an oil well it is desirable from time to time to determine the location of the fluid level within the well for the purpose of determining the type of pumping apparatus most desirable to be used, determining the rate of flow of oil into the well, and for making other determinations desirable in the most efficient operation of the well.

Prior methods of determining the location of the fluid level or the location of other obstructions in the well have been generally of two types, one in which measuring apparatus has been lowered from the ground surface to determine by the length of cable or the line extended into the well, the depth or location of the fluid or other obstructions encountered by the instrument as it is lowered. Among devices to be lowered into the well is also included a pressure recorder which may be lowered into the well on a wire, the length of which is metered to determine the static pressure in the well at different levels, a variation of which includes a pressure recorder with a clock driven chart lowered on the bottom of the pump to obtain a record of the operating pressures or levels of the fluid. A further variation is that of lowering a bailer upon a rope and either measuring the wetted surface of the rope or repeatedly lowering the bailer until it brings up fluid, measuring the length of the line upon such

Defendant's Exhibit B—(Continued)

occurrence. The other method is that of producing sound waves in the well and noting the elapsed time between the introduction of the sound and its return as an echo from the surface of the liquid or other obstruction encountered.

Neither of these methods is satisfactory, the first having the disadvantage of requiring the removal of oil flow tubing, sucker rods and other apparatus normally disposed in the well prior to the time the instrument is inserted in and lowered into the well, requiring a considerable length of time both for the removal of such apparatus, the reinsertion of the apparatus, and the making of the actual measurement. The other method is unsatisfactory primarily because of the relatively low intensity or energy which can be employed in the sound wave so that the echo received back is of such low energy as to prevent its accurate detection and, further, little or no distinction is made by reason of such low energy between various types of obstructions encountered by sound waves.

A third method, namely, that of introducing a shock of relatively high intensity into the well, creating thereby a pressure wave which travels through the well, and measuring the elapsed time between the introduction thereof and the echo thereof, to give an indication of the depth of the fluid level and other obstructions, has been introduced, one form being that of creating a relatively loud noise such as a shot or an explosion in the well, another

Defendant's Exhibit B—(Continued)

form being illustrated and described in United States Letters Patent No. 2,047,974, issued to Harold J. Wyatt and Paul E. Lehr on July 21, 1936. This latter method has the desirable characteristic of permitting the employment of relatively high intensity in the wave or impulse produced in the well and it is an object of my invention to improve upon the method disclosed in that patent and to eliminate or materially reduce factors of error encountered in the employment of that method.

Another object of my invention is to provide a method of measuring the location of fluid level or other obstructions in well bores, in which the intensity of the pressure impulse introduced into the well may be varied to compensate for well depth and the character of the gaseous media through which the wave must travel to produce an echo of sufficient intensity to permit the same to be readily detected and translated.

Another object of my invention is to provide a method as set forth in the preceding paragraph wherein the pressure impulse may be so varied as to allow the detection and the separate determination of the location of a plurality of obstructions which may be encountered in the well.

Another object of my invention is to provide a method for the measurement of the location of fluid level or other obstructions in a well bore in which the pressure impulse introduced into the well produces an indication both of the fluid level and

Defendant's Exhibit B—(Continued)

of the location of other obstructions in the well bore.

Another object of my invention is to provide a method of the character set forth in the preceding paragraph wherein the same pressure impulse introduced into the well to measure the fluid level or the location of other obstructions is employed to determine the velocity of the wave in the particular media encountered in the well.

Another object of my invention is to provide a method as set forth in the preceding paragraph wherein, knowing the location of one or more obstructions, tools or other devices in the well bore, the velocity of the wave within the well bore may be accurately determined from echoes produced thereby and enabling an operator to determine the unknown location of the fluid level by the mere measure of the elapsed time between the introduction of the impulse into the well and the reception of a distinguishable echo from the fluid level, without necessitating introduction of corrective factors or other separate measurement of and determination of the character of the media in the well.

Another object of my invention is to provide a method for determining the location of fluid levels in well bores in which the location of and the number of tubing sections in the well may be determined by the same pressure wave created to measure the depth or the location of the fluid level.

Defendant's Exhibit B—(Continued)

Other objects of my invention will be apparent from a study of the following specifications, read in connection with the accompanying drawings, wherein

Fig. 1 is a diagrammatic view illustrating a typical well cross section and the location and character of the apparatus required for determining the fluid level or location of other obstructions in the well in accordance with my method;

Fig. 2 is a diagrammatic view illustrating the type of record or indication which may be made with my method in its simplest application;

Fig. 3 is a diagrammatic view similar to Fig. 2 and illustrating the type of record or indication which may be made with my method but in which echoes produced by intermediate obstructions are not amplified; and

Fig. 4 is a diagrammatic view similar to Figs. 2 and 3 and illustrating the type of record or indication which may be made with my method, including the amplification of echoes from intermediate obstructions.

The method disclosed in United States Letters Patent issued to Wyatt and Lehr, hereinbefore referred to, is briefly that of introducing into a well bore a pressure impulse, either positive or negative, which may have any desired frequency as by the introduction into the well of a quantity of gas of known pressure and volume, the introduction of this impulse into the well producing a wave which will travel down the well until it encounters the

Defendant's Exhibit B—(Continued)

fluid surface in the well and then the wave will be reflected and will travel back up the well to the ground surface where the echo or return wave may be detected, the measurement of the elapsed time between the production of the impulse and the arrival at the ground surface of the echo constituting a measure of the location of the fluid level by the simple calculation of the elapsed time multiplied by the rate of travel or the velocity of the wave in the well. In making such calculations, it is correctly assumed that the wave will act like an acoustical wave and its velocity will be the same as that of a sound wave. In air at normal temperatures and approximately sea level pressures, this rate would be 1100 feet per second but the gaseous content or media in the well is ordinarily not the same as air and correction must be made for the density, temperature or other characteristics of the particular media encountered in the well, it being well known that the higher the temperature or the lower the density of the gaseous media through which the impulse travels, the greater the velocity of the wave.

In employing the method as set forth in the said patent, an approximation of the fluid level may be readily determined and this approximation or measurement may be determined in a relatively short length of time, without requiring the removal or disturbance of any of the apparatus contained within the well bore. However, to determine the fluid level with considerable accuracy, the rate of travel of the wave in the particular media encountered in

Defendant's Exhibit B—(Continued)

any particular well must be known or must be determined since the density, temperature and character of the gaseous media in wells varies in each different oil field and in each individual well. I provide means for readily determining the pressure wave velocity in any particular well, which may be arrived at as follows:

In Fig. 1, I have illustrated a typical oil well comprising the earth bore 1, usually lined with casing 2 or pipe of relatively large diameter, extending from the ground surface at 3 to the oil bearing sands at 4 where the casing is either perforated or is provided with a perforated liner through which the oil from the sands may enter to the interior of the casing. The casing is, of course, constructed of a plurality of lengths of pipe secured together by couplings or collars in any well known manner. A second pipe or string of pipes extend down through the casing 2, this string of pipe being known as the oil flow tubing, indicated at 5, extending from the ground surface down to a position disposed below the level of the fluid in the well, which is indicated at 6, the lower end of the tubing string 5 having a pump 7 of any desired character located therein. Such pumps are usually operated by means of a string of sucker rods 8 which extend upwardly through the tubing string 5.

It is the common practice to employ in the tubing string 5 a tubing catcher 9 which may be of any of the well known constructions, the tubing catcher being usually located a relatively short dis-

Defendant's Exhibit B—(Continued)

tance above the level of the pump in the well so that should the tubing string break the tubing catcher 9 will grip the casing and prevent complete destruction of the tubing string. One or more of the tubing catchers 9 may be distributed throughout the length of the tubing string 5.

The tubing string 5 is constructed of a plurality of lengths of pipe coupled together by means of collars 10, which collars are usually of somewhat larger outside diameter than the outside diameter of the tubing from which the oil flow tubing is made.

Hence it will be noted that in the ordinary oil well there are a plurality of obstructions, each of which is capable of receiving and reflecting a sound wave or pressure wave passing down through the well, these obstructions including the fluid surface 6, the tubing catcher 9 and each of the collars 10 of the tubing string.

In most wells the length of the tubing string between the ground surface 3 and the pump 4 is known, that is, records are usually kept showing the length of each tubing string section and the number of such sections located within any given well. Particularly, records are usually kept as to the location along the tubing string of the catcher 9 so that by referring to these records an absolute calculation or determination of the distance between the ground surface and the tubing catcher or liner top is known. Hence to determine the loca-

Defendant's Exhibit B—(Continued)

tion of the fluid level 6, it is only necessary to produce in the well a pressure impulse which will create the low frequency wave, and then translate the echoes received from the well in terms of echo impulses received from the tubing catcher or liner top and from the liquid surface. By comparing the time lapse between the production of the pressure impulse and the receipt of the echo from the tubing catcher with the time lapse between the creation of the pressure impulse and the receipt of the echo from the fluid surface, a positive and accurate measurement of the location of the fluid level may be obtained. That is, if the known location of the tubing catcher is 5000 feet below the ground surface and it is desired to know the height of the fluid in the well, all that is necessary is to produce a pressure impulse, note or record the echo from the tubing catcher, and note or record the echo received from the fluid surface.

The time lapse between the creation of the pressure impulse and the receipt of the echo from the tubing catcher denotes the velocity of the pressure wave in the particular media encountered in that particular well so that by measuring the additional elapsed time between the receipt of the echo from the tubing catcher and the receipt of the echo from the fluid surface, an accurate measurement may be obtained and no compensation need be made for possible errors due to different velocities of waves in different media because the mean velocity of the wave from the ground surface to the tubing catch-

Defendant's Exhibit B—(Continued)

er and return is the same as the mean velocity of the wave from the ground surface to the fluid surface and return.

The only item which must be provided for is that of producing a pressure wave echo of such magnitude and of such character that the echo from the tubing catcher can be distinguished from the echo received from the fluid surface.

As illustrated in Fig. 1, this distinction may be readily made by providing a suitable source of fluid pressure indicated at 11 which may be a tank, compressor or other source of fluid pressure at any desired value. It follows, of course, that the pressure impulse which must be produced in the well must be at a greater pressure than the pressure of gases in the well so that the pressure source 11 must be capable of delivering a pressure impulse having a considerable differential over the static pressure of gases in the well or flowing therefrom. For example, if the well gases at the surface of the well are at a pressure of 500 pounds per square inch, the source of fluid pressure 11 must be capable of delivering, say, 600 pounds per square inch or more in order to create a pressure impulse of, for example, 100 pounds pressure differential.

The pressure source 11 is illustrated as being coupled to a pressure chamber 12, one end of which is connected as by means of tube 13 and valve 14 to the pressure source 11, while the opposite end of the pressure chamber 12 is connected by means of a nipple 15, a quick opening valve 16 and a nip-

Defendant's Exhibit B—(Continued)

ple 17 to a length of pipe 18 which is in turn coupled as indicated at 19 to the well casing 2. The pressure chamber 12 is preferably provided with a suitable indicating pressure gage 20 by which the pressure within the pressure chamber 12 may be readily measured. Thus for the production of the pressure wave all that is necessary is to close valve 16, open valve 14 and allow pressure to be built up in the pressure chamber 12 to the desired pressure value, say, 600 pounds per square inch. Then the valve 14 is closed and valve 16 opened, allowing an impulse of 600 pounds per square inch to be injected into the well casing (the static pressure in which is, for example, 500 pounds per square inch).

A receiving device for receiving and registering the echoes of the pressure impulse from the various obstructions within the well is illustrated as including the pipe 18 and pressure responsive device coupled thereto through a valve 21 to a diaphragm chamber 22, permitting a flexible diaphragm 23 to be placed into communication with the casing 2 whenever the valve 21 is opened. To control the sensitivity of response of the diaphragm 23 and in order to prevent undue distortion of the diaphragm 23 by the static pressure in the well and to avoid damage which would result therefrom, I prefer to allow the static pressure in the well casing 2 and pipe 18 to be equalized on both sides of the diaphragm 23 as by providing a by-pass 24 providing a restricted passage through which gas pressure

Defendant's Exhibit B—(Continued)

in the chamber 22 on one side of the diaphragm may pass to the opposite side of the diaphragm, the filter 25 being interposed in the by-pass if desired to dry out the gas and prevent undue corrosion of the more delicate parts of the device contained in the diaphragm chamber 22. Attached to the diaphragm 23 is a mirror 26. In the front wall 34 of the diaphragm chamber 22 I mount a lens 35, through which light from a suitable light source 36 may pass into the chamber 22 to be reflected by the mirror 26, the reflected beam 37 passing back through the lens 35, as a ribbon beam which may be reflected or directed upon a ground glass screen 38 and upon a recording chart or strip of sensetized tape 39 to make a permanent record of the path described by the light beam 37. Suitable reflectors, such as indicated at 40, may be employed to direct the beam in any desired direction while a reflector 40a may be interposed in a portion of the ribbon beam 37 to direct a portion thereof upon the screen 38, suitable condenser lenses 40b and 40c being interposed in the beam to draw the same to a point beam upon the screen 38 and tape 39.

Thus as the pressure within the casing 2 is varied as by the pressure wave resulting from the pressure impulse created within the casing 2, the mirror 26 will be moved, the amplitude of its movement representing the amplitude of the pressure variation. As the echo of the pressure impulse from any obstruction within the well is received upon the diaphragm 23, the mirror 26 will be moved

Defendant's Exhibit B—(Continued)

in accordance with the amplitude of the echo impulse and will cause the echo impulses to be registered for observation, both by directing the light beam 37 upon the ground glass 38 where the amplitude of the echo may be visually observed and by directing the light beam 37 upon the recording tape 39, a permanent record of the pressure wave which is created within the casing 2 may be made and this wave or chart will show peaks of varying amplitude, each of which peaks represents an echo from a particular obstruction within the well, either the tubing collars 10, the tubing catcher 9 or the fluid surface 6.

The sensitized strip 39 may be arranged to be driven at any desired speed by means of a variable speed motor 41 coupled to a suitable source of current 42 through a rheostat or other speed adjusting device 43 so that the tape or strip 39 may be driven at variable speeds.

By employing some device which will produce upon the record strip 39 a time lapse measurement, a direct comparison between the path described by the light beam and the lapse of time may be accomplished. I prefer to provide such mechanism including means for producing upon the strip 39 a series of dots or marks, each of which represents a fraction of a second, the line of dots or marks extending substantially parallel to the general direction of the wave chart described by the light beam 37. This may be readily accomplished by providing a disc 44 having a plurality of openings 45 therein adapted to

Defendant's Exhibit B—(Continued)

be rotated in the path of a secondary light beam 46 emanating from the light source 36. The light beam 46 passing through the openings of the disc 44 may be projected upon the same sensitized strip 39 to describe a series of marks thereon, one for each of the openings 45.

One of the openings 45a is preferably larger than the remainder so that upon each revolution of the disc 44 a distinguishing mark will be produced. Thus by providing ten openings 45, a series of marks 48a may be produced upon the record strip 39 representing ten equal divisions. The tenth mark being produced by the large opening 45a is of greater length or of greater size or in some other manner distinct from the remaining nine marks. By providing the disc 44 with any suitable time mechanism such as a synchronous motor 47, the marks produced upon the charts will represent lapse of time; for example, each mark representing 1/10th of a second while the space between the distinct marks will represent lapses of one second each.

Due to the fact that the depth of wells varies considerably and, further, due to the fact that conditions of obstruction or constriction of the space between the well casing 2 and the tubing string 5 varies considerably in different wells, the same pressure differential cannot be used successfully in all wells and it is necessary to vary the pressure impulse through considerably wide limits, dependent upon the conditions encountered at a particular

Defendant's Exhibit B—(Continued)

well. For this reason I prefer to direct a portion of the beam 37 upon the ground glass screen 38 so that by firing one charge of gas pressure into the well and observing the path described by the light beam, a determination of whether or not the correct pressure impulse is being used may be made. For example, one pressure impulse which is estimated to be correct for a given well may not produce a sufficient fluctuation in the echo waves received from the tubing catcher and the fluid surface, and a higher pressure or greater quantity of gas must be used in order to create the desired impulse. Thus by observing the effect of a succession of pressure impulses liberated into the well, the person making the survey will be able to determine which of the echoes rebounds from the tubing catcher and which of the echoes rebounds from the fluid surface and thus determine when distinguishable echoes are being received from the different obstructions in the well.

The typical desired configuration of the path described by the light beam 37 is indicated in Fig. 2 wherein "a" represents the path described by the light beam as a result of the pressure wave created by a discharge of gas from the chamber 12 into the well casing. From an inspection of the line a, it will be noted that this line is a relatively straight but somewhat wavy line, having distinct peaks at b, c and d. The peak b is that which will be produced by the deflection of the diaphragm 23 when the impulse of gas from the chamber 12 is liberated

Defendant's Exhibit B—(Continued)

into the casing 2. At a predetermined time thereafter, dependent upon the velocity of the wave in the particular well, a peak c will be produced as a reflection from the tubing catcher 9, while at a predetermined time thereafter an additional peak or series of peaks will be produced at d as a reflection of the wave from the fluid surface.

Thus by observing the effects of a series of pressure impulses of different intensity or pressure, the operator may determine which impulse is most desirable to produce the distinctly recognizable and differentiatable peaks c and d, allowing him to differentiate between echo from the tubing catcher (or such other obstructions as may be known to be in the well) and the echo from the fluid surface. As hereinbefore stated, knowing the depth or location of the tubing catcher 9, the comparison of the elapsed time between the peaks b and c and the elapsed time between the peaks b and d, an accurate determination of the fluid level may be produced.

After the most desirable magnitude of pressure impulse has been determined, the motor 41 may be set into action and a permanent record of the path described by the light beam may be made upon the sensitized film 39 with assurance that the various peaks b, c and d will be readily distinguishable upon the diagram so produced.

As will be observed from an inspection of Fig. 2, the diagram on the strip 39 also shows the plurality of spaced dots or other means of indicating

Defendant's Exhibit B—(Continued)

elapsed time, such series of dots being indicated at 48a.

Having made a diagram as indicated in Fig. 2, a direct measure and determination of the fluid depth may be achieved. Also it will be observed that by selecting impulses of the desired magnitude, reflections from other obstructions in the well may be noted and recorded, thus assisting in the location and determination of other restrictions as well as a measurement of the fluid level.

For example, each of the collars 10 of the tubing string will produce a distinct echo differentiatable from the echoes from other sources. This allows the accurate measurement of the fluid level in a well where, by reason of failure to keep records or loss of records, the location of the tubing catcher is not known or wherein the catcher is submerged or is omitted. For example, in some wells tubing has been drawn out and replaced by other tubing and no record has been made of the lengths of tubing drawn out or the lengths of each section drawn out or the lengths or number of tubing sections employed to replace them so that to merely compare the time distance between the peaks b and c would not give a true indication of the velocity of the wave in the particular well. However, if it is reasonably assured that each of the tubing lengths is approximately the same, and the usual practice in oil wells is to employ tubing lengths in a given well, all of which are approximately the same, an indication of the number of tubing lengths located within any

Defendant's Exhibit B—(Continued)

given well, multiplied by the average length of a tubing section, will give a true measure of the location of the tubing catcher or the location of the pump or other device which constitutes an obstruction in the well. For example, by selecting a desired pressure impulse, by comparison of a succession of pressure impulses and the waves produced thereby, upon the ground glass 38, a wave or line of the character indicated at a in Fig. 3 may be produced wherein, though it is still wavy, it is produced by a series of peaks e. By counting the number of these peaks, each of which represents a reflection back from a collar 10, the number of lengths of tubing between the peaks b, c and d may be determined.

However, in actual practice it is found that irregularities in the annular space between the tubing and the casing, such as may be caused by imperfect abutment of adjacent casing sections or the presence of tubercules upon either the casing or the tubing will produce undesired echoes and will produce upon the record chart peaks which cannot readily be distinguished from those resulting from the echoes from the tubing collars, and I prefer therefore to provide some means which will be so tuned with the tubing collar echoes as to amplify or accent them and which will tend to dampen or filter out the undesired disturbance vibrations. As will be understood by those familiar with acoustics, if upon the multiplicity of sound waves emanating from the well as a result of the desired echoes and the disturbances there is superimposed another wave

Defendant's Exhibit B—(Continued)

so tuned to the desired echo wave as to beat with it, the desired wave will be amplified and accented while the other or disturbance waves will tend to be damped out.

By selecting the correct length for the pipe 18, that is, by selecting the correct distance between the casing 2 and the diaphragm 23, a tuned wave may be produced which will affect the movements of the diaphragm 23. Since it is desired to count the number of tubing collars, all that is necessary is to lengthen or shorten the pipe 18 until it is tuned to one of the harmonics of the impulses or echoes produced by the collars 10. From experience it has been found that selection of the pipe 18 of approximately on-third of the length of a section or joint of the tubing 5, a third harmonic is produced which beats with the impulses echoed from the tube collars 10 to produce magnified or amplified peaks e and permits the ready distinguishing of the impulses produced by the collars 10 from other impulses.

I prefer, however, to employ in the length of the pipe 18 an adjustable coupling 19 which allows the accurate lengthening or shortening of the pipe 18 until, by observing the path of the light beam upon the ground glass 38, a distinct pattern is made represented by the line a on Fig. 4, in which each of the intermediate peaks e is amplified as indicated in Fig. 4 so that it is readily recognizable.

The adjustment of the coupling 19 should be made until, with a given pressure impulse, a uniform deflection of the mirror 26, that is, a uniform ampli-

Defendant's Exhibit B—(Continued)

tude of the peaks e, is achieved, and by observing this upon the ground glass 38 the operator will note when the pipe 18 is of such length as to be "tuned" with the tubing lengths.

Thus, even though the location of the tubing catcher is not known, if the average length of tubing section is known, the production upon the strip 39 of a diagram such as shown in Fig. 4 allows the counting of each of the collars 10 and a clear understandable record is made of the length of tubing string between the impulses b, c and d, permitting the quick and accurate location and determination of the exact level of the fluid in the well.

As is described and claimed in my copending application Serial No. 270,866, filed April 29, 1939, an elongated tube or pipe 53 coupled as by means of a short pipe 54 to the pipe 18 and controlled by a valve 55 in such manner as to permit gas from the casing 2 to flow through the pipe or tube 53, thus providing in the pipe 53 an atmosphere corresponding to the atmosphere or gaseous medium in the casing 2. An open exhaust pipe 56 leads from the opposite end of pipe 53 open to the atmosphere or connected to a gas flow line so that the pressure within the pipe or tube 53 will remain substantially constant as of the value of the gas in the casing 2. Near one end of the tube 53, a diaphragm 57 may be provided and arranged to be vibrated at any desired frequency as by coupling the diaphragm 57 by a pipe 58 open to the atmosphere at 58a, to a

Defendant's Exhibit B—(Continued)

source of fluid pressure, such as compressed air, indicated at 59. A rotary valve 60 is interposed in the pipe 58 and arranged to be driven by means of a variable speed motor 61 regulated as to speed by means of a suitable rheostat or other controlling device 62 so that by rotating the motor 61 at any speed a series of pressure impulses will be created in the pipe 58, and will beat upon diaphragm 57 to create a pressure wave in the tube or pipe 53 of known frequency, the frequency being variable by varying the speed of motor 61.

At the opposite end of the pipe 53 I couple a pressure responsive device which may be constructed in the same manner as the diaphragm chamber 22 and diaphragm 23 hereinbefore described. This pressure responsive device is illustrated at 63 coupled directly to the end of the pipe 53, the diaphragm 64 of which receives the impulses transmitted through the pipe 53 to vibrate in response thereto and to move a mirror 65 in the same manner as was described with reference to the mirror 26. The mirror 65 reflects a light beam from a suitable source 66 upon a polygon of mirrors 67 revolved by means of an adjustable speed motor 67a at a speed synchronous with the speed of the motor 61 so that the amplitude and uniformity of the vibrations of the diaphragm 64 may be visibly observed.

As is well known in the art, each gaseous medium, variable as to density, temperature, etc., is resonant to pressure waves or sound waves of predetermined frequency. Thus by varying the speed of operation

Defendant's Exhibit B—(Continued)

of the motor 61 until the pressure impulse created by the diaphragm 57 makes one round trip (or multiple thereof) to the diaphragm 64 and back to the diaphragm 57 in time to just synchronize with the next impulse created by the diaphragm 57, the pattern described by the beam of light on the mirrors 67 will show maximum amplitude, and noting the frequency of the impulses produced upon the diaphragm 57 (that is, noting the speed of the motor 61) the velocity of the sound through this particular gaseous medium may be readily determined by comparing this frequency with the frequency at which a condition of perfect resonance is achieved in the pipe 53 with air in it.

It will therefore be observed that I have provided a method of determining the location of obstructions in wells and accurately locating and measuring the fluid level in a well without the necessity of removing any of the apparatus from the well, the entire measurement and determination being accomplished in a relatively short time.

It will be understood by those skilled in the art that the creation of pressure impulses within the well may be accomplished by decreasing the pressure in the well instead of admitting a charge of gas from the pressure chamber 12 into the well. For example, if the pressure in the well is relatively high, the valve 16 in the pressure chamber may be closed and the valve 14 opened, allowing the pressure in the chamber 12 to reduce to some value less than the casing head pressure of the well. Then by

Defendant's Exhibit B—(Continued)

closing valve 14, and opening valve 16 a measured quantity of gas will rapidly discharge or surge into the chamber 12, creating a pressure impulse within the well which acts in the same manner as hereinbefore described for the introduction of pressure from the tank or other source 11.

It will also be understood that if desired special constrictions may be placed in the well for future measurements of the fluid level therein to take the place of the tubing catcher 9. Such constrictions could comprise a closed cylinder of pipe surrounding and attached to one of the tubing sections when the tubing is run into the well and by noting and recording the location of such constriction, the future measurements of the fluid level by my pressure impulse method can be readily determined, employing the reflection of the wave from the resticting member in place of the reflection from a tubing catcher 9 or other restriction in the well.

While I have shown and described the preferred embodiment of my invention, I do not desire to be limited to any of the details of construction shown and described herein, except as defined in the appended claims.

HWM:MM

lc

I CLAIM:

1. The method of accurately determining the unknown location of an obstruction in a well having a string of tubing therein constructed of a plu-

Defendant's Exhibit B—(Continued)

rality of lengths of tubing, each of approximately the same length and connected to each other by couplings, which consists in creating a pressure impulse in the annular space between the tubing and casing of the well, registering the echoes from the tubing collars and from said obstruction, and counting the tubing collar echoes occurring between the creation of the pressure impulse and the echo from the unknown obstruction, to determine the location of the unknown obstruction.

2. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating an acoustical impulse in the annular space between the tubing and the well casing to produce echoes from portions of the tubing string distinguishable from each other and from the echo from the unknown obstruction, observing the lapse of time between the arrival at a predetermined point of the echoes from successive portions of the tubing string to thereby determine the velocity of the pressure wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

3. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating an acoustical impulse in the annular space between the tubing and the well casing of such magnitude as

Defendant's Exhibit B—(Continued)

compared with the depth of the well and the resistance to pressure wave transmission therethrough as will produce echoes from portions of the tubing string distinguishable from each other and from the echo from the unknown obstruction, observing the lapse of time between the arrival at a predetermined point of the echoes from successive portions of the tubing string to thereby determine the velocity of the pressure wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

4. The method of determining the unknown location of an obstruction in a well having a casing with tubing therein restricting the ^ ~~volume~~ volume of the annular space within the casing and having another obstruction therein at a known location above the unknown obstruction, which consists in creating in the annular space an acoustical impulse to produce echoes from different obstructions distinguishable from each other, observing the ^ ~~lapse of time~~ time lapse between the creation of the impulse and the arrival at a predetermined point of the echo from the known obstruction ^ ~~to thereby determine the velocity of the pressure wave in that particular well, and measuring the lapse of time~~ comparing with said time lapse the time lapse between the creation of the impulse and the arrival at said predetermined point

Defendant's Exhibit B—(Continued)

of the echo from the unknown obstruction.

5. The method of determining the unknown location of an obstruction in a well having a casing with tubing therein restricting the ^ ~~volumn~~ volume of the annular space within the casing and having another obstruction therein at a known location above the unknown obstruction, which consists in creating in the annular space an acoustical impulse of such magnitude as compared with the depth of the well and the resistance to pressure wave transmission therethrough as will produce echoes from different obstructions distinguishable from each other, observing the lapse of time between the creation of the impulse and the arrival at a predetermined point of the echo from the known obstruction to thereby determine the velocity of the pressure wave in that particular well, and measuring the lapse of time between the creation of the impulse and the arrival a at said predetermined point of the echo from the unknown obstruction.

6. The method of determining the unknown location of an obstruction in a well, which consists in placing another obstruction in the well at a known depth in the well, creating a pressure impulse in the well, observing the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo thereof from the obstruction of known location, and measuring the lapse of time between the creation of

Defendant's Exhibit B—(Continued)

the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

7. The method of determining the unknown location of an obstruction in a well having a casing with tubing therein restricting the volume of the annular space within the casing and having an approximately known depth and a known pressure of gas within said space, from which the approximate magnitude of acoustical impulse required to traverse the restricted space and produce echoes from the several obstructions in the well may be estimated, which consists in introducing into said space between the casing and tubing a series of acoustical impulses, each of different magnitude appoximating the estimated magnitude to produce from each impulse echoes from the different obstructions in the well, observing the echoes that are produced by each impulse to select the one that produces distinguishable echoes from each of the obstructions in the well, and recording the echoes of an impulse of the selected magnitude in the relative times and order in which they are received at the ground surface.

Defendant's Exhibit B—(Continued)

In Testimony Whereof I affix my signature.

CRANFORD P. WALKER

OATH

State of California
County of Los Angeles—ss.

Cranford P. Walker, the above named petitioner, being duly sworn, deposes and says that he is a citizen of the United States, and resident of San Marino, in the County of Los Angeles, State of California, that he verily believes himself to be the original, first and sole inventor or discoverer of the Method of Measuring Location of Obstructions in Deep Wells, described and claimed in the annexed specifications; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to the filing of his parent application for United States Letters Patent Serial No. 162,699, of which this application is a division, or in public use or on sale in the United States for more than two years prior to the said parent application; that said invention has not been patented in any country foreign to the United States on any application filed by him or his legal representatives or assigns more than twelve months prior to this application; and that no application for patent on said invention has been filed by him or his legal

Defendant's Exhibit B—(Continued)

representatives or assigns in any country foreign to the United States.

CRANFORD P. WALKER

Subscribed and sworn to before me, this 22nd day of September, 1939.

MARJORIE McKAY

Notary Public in and for the County of Los Angeles, State of California

(Notarial Seal)

My Commission Expires July 14, 1941.

867

RECEIVED

OCT 4 1900

Division 5. Paper No. 2

[redacted] DIV 5

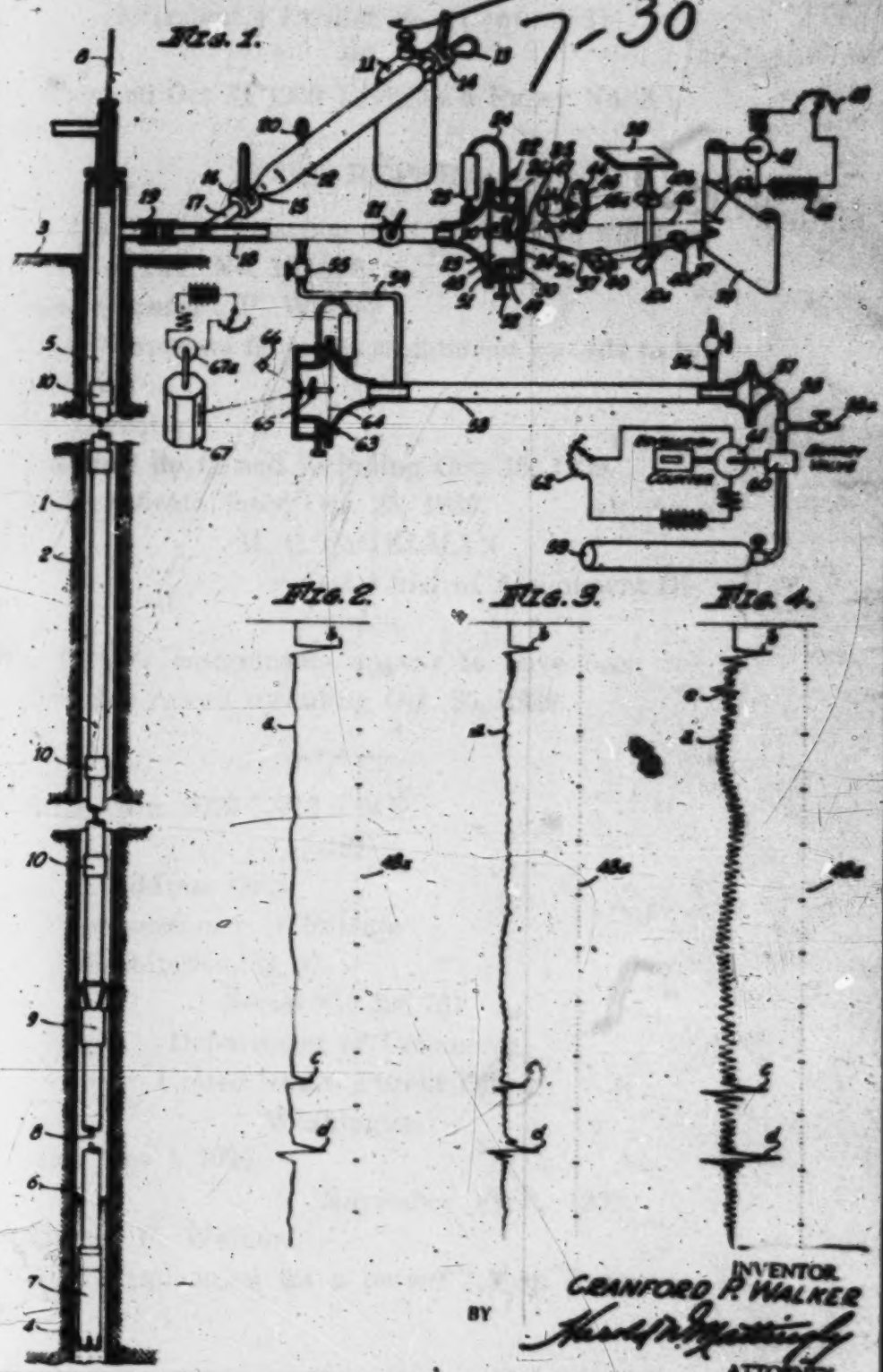
296781

Print of drawing as originally filed.

944

7-30

O.G. FIG. CLASS 1/21 SUB. CLASS 0.5



INVENTOR
CRANFORD P. WALKER

BY Harold N. Mattingly

ATTORNEY.

5

296781 30

181-0.5

Defendant's Exhibit B—(Continued)

401

Received Oct 31 1939 Division 5 Paper No. 3.

Div. 5.

TITLE REPORT

No. 296,781, Continuation of S. N. 270,865, which is a Div. of Ser. No. 162,699.

Name Cranford P. Walker

The title appears from the assignment records to be vested in:

The Inventor.

Examined up to and including Oct. 16, 1939.

This certificate dated Oct. 25, 1939.

H. C. SPIELMAN

Asst. Chief of Assignment Division.

No further assignments appear to have been received for record including Oct. 25, 1939.

Div. 5—Rm. 3077 LWJ:FME

181

Address Only

The Commissioner of Patents

Washington, D. C.

Serial No. 296,781

Department of Commerce

United States Patent Office

Washington

Mailed Nov 1 1939

November First, 1939.

Cranford P. Walker

Your Application for a patent for an Improve-

Defendant's Exhibit B—(Continued)

ment in Method of Measuring Location of Obstructions In Deep Wells filed Sept. 25, 1939 has been examined and Allowed with 7 claims.

The final fee, Thirty Dollars, With $1 Additional For Each Claim Allowed In Excess of 20, must be paid not later than Six Months from the date of this present notice of allowance. If the final fee be not paid within that period, the patent will be withheld; See Revised Statutes, Section 4885 As Amended By Act Of Congress Approved August 9, 1939.

The office delivers patents upon the day of their date, on which date their term begins to run. The preparation of the patent for final signing and sealing will require about four weeks, and such work will not be begun until after payment of the necessary final fee.

When the final fee is paid, there should also be sent, Distinctly And Plainly Written, the name of the Inventor, Title Of The Invention, And Serial Number As Above Given, Date Of Allowance (which is the date of this circular), Date of Filing, and, if assigned, the Names Of The Assignees.

If it is desired to have the patent issue to an Assignee Or Assignees, an assignment containing a Request to that effect, together with the Fee for recording the same, must be filed in this office on or before the date of payment of the final fee.

After issue of the patent, uncertified copies of the drawings and specifications may be purchased at the price of Ten Cents Each. The money should

Defendant's Exhibit B—(Continued)

accompany the order. Postage stamps will not be received.

The final fee will Not be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

Notice.—When The Number Of Claims Allowed Is In Excess Of 20, No Sum Less Than $30 Plus $1 Additional For Each Claim In Excess Of Twenty Can Be Accepted As The Final Fee.

Respectfully,

CONWAY P. COE

Commissioner of Patents.

This Application Cannot Be Renewed.

H. W. Mattingly,
720 Pacific Finance Bldg.,
621 S. Hope St.,
Los Angeles, California.

[Printed in Margin]: Uncertified Checks Will Not Be Accepted.

[Printed in Margin]: In Remitting the Final Fee Give the Serial Number at the Head of This Notice.

Defendant's Exhibit B—(Continued)

Mail Division May-1 1940 U. S. Patent Office

FINAL FEE PAID TO THE COMMISSIONER OF PATENTS

May—1-40 214483 B—Check— 30.00

(Be careful to give correct Serial No.)

Serial No. 296781

Inventor:

Cranford P. Walker

Patent to Be Issued to

Cranford P. Walker

Name of Invention, As Allowed:

Method of Measuring Location of Obstructions in Deep Wells

Date of Payment:

May 1 1940

Fee

$30

Date of Filing:

Sept. 25 1939

Date of Circular of Allowance:

Nov. 1 1939

The Commissioner of Patents will please apply the accompanying fee as indicated above.

H. W. MATTINGLY

Attorney.

Send Patent to

H. W. Mattingly

621 So. Hope St.,

Los Angeles Calif.

Final fees will not be received from other than the applicant, his assignee or attorney, or a party

Defendant's Exhibit B—(Continued)

in interest as shown by the records of the Patent Office, Nor Will They Be Applied in Pending Applications.

Please defer issue 3 months.

July 30/40

Address Only
The Commissioner of Patents
Washington, D. C.

Department of Commerce
United States Patent Office
Washington

May 7, 1940

Harold,W. Mattingly
720 Pacific Finance Bldg.
621 S. Hope St.
Los Angeles, Calif.

Applicant Cranford P. Walker
Serial No. 296781
Filed Sept. 25, 1939
For Method of Measuring Location of Obstructions in Deep Wells
Final Fee May 1, 1940
Issue Date July 30, 1940

Sir:

Your letter requesting deferment under Section 4885 R. S. has been received.

Respectfully.

J. A. BREARLEY,
J. A. Brearley,
Chief Clerk.

Defendant's Exhibit B—(Continued)

Application Div. May 15 '40 U. S. Patent Office
Received May 15 1940 Division 5 Paper No. 4
Assoc. Power of Attorney

In the United States Patent Office
Cranford P. Walker
Method of Measuring Location of Obstruction in Deep Wells
Filed September 25, 1939
Serial No. 296,781

ASSOCIATE POWER OF ATTORNEY

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Please recognize Mr. Raymond Jones, of 1427 Eye Street, N.W., Washington, D. C., as associate in the above entitled application.

HAROLD W. MATTINGLY
Attorney of Record

HWM:VM

Allowed Nov. 1. Div. 5.
Rule 78 May 15 1940 Orders No. 2698, 2801, 3311
U. S. Patent Office May 15 1940 Issue Division
Received May 15 1940 Division 5. Paper No. 5
Pet (R-78) & Amdt. A.

In the United States Patent Office
Cranford P. Walker
Method of Measuring Location of Obstruction in Deep Wells
Filed September 25, 1939

Defendant's Exhibit B—(Continued)

Serial No. 296,781

[Marginal Note]: 5 Wec def. July 30 Johnson. O.K. L.W.J.

Los Angeles, California,
May 15, 1940.

AMENDMENT UNDER RULE 78

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Please amend the above entitled application under the provisions of Rule 78 and without withdrawing the application from issue, as follows:

√ √

Claims 4 and 5, line 3, correct the spelling of "volume".

√Claim 5, line 16, correct spelling of "arrival".

√Add the following claim:

A1

—8. The method of determining the unknown location of an obstruction in a well having a string of pipe therein consisting of sections of known mean length connected by couplings, which consists in creating an impulse in the well adapted to produce an echo from each of a plurality of successive couplings and from the obstruction of unknown location, and sequentially registering the impulse and such echoes in spaced relation to each other proportional to the actual relative spacing of the couplings and the unknown obstruction, and computing the distance to the unknown obstruction from said known mean length between successive couplings and the number of registered coupling echoes.

Defendant's Exhibit B—(Continued)

REMARKS

In reviewing this application immediately prior to the payment of the final Government fee, it was discovered that minor errors were present requiring correction as indicated above.

It is believed that the applicant is obviously entitled to new Claim 8, which defines the production of a chart in which the relative spacing of the echo registrations from the pipe joints or tubing joints constitutes a graphic representation of the distance between the successive joints so that the relative spacing of these echo registrations along the chart and the spacing of the registration of the echo from the unknown obstruction are proportionate to the actual spacing of the tubing joints and the fluid level or other unknown obstruction along the well. Thus, knowing the lengths of the tubing or pipe sections, the spacing of the registrations constitutes a measure or scale by which the distance to the unknown obstruction may be readily measured or computed.

It should be obvious that entry of claim 8 will necessitate no additional search and that this claim may be entered in this application under the provisions of Rule 78.

Respectfully submitted,

RAYMOND JONES.

Associate Attorney.

Defendant's Exhibit B—(Continued)

Entry Recommended Under Rule 78.

C. W. ROBINSON
Examiner

Entry Approved

HENRY VAN ARSDALE
Acting Commissioner of Patents

Div. 5 Room
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name

Paper No. 6

All communications respecting this application should give the serial number, date of filing, and name of the applicant

3077 LWJ:FME
Department of Commerce
United States Patent Office
Washington

May 16, 1940

Mailed May 17 1940.
Raymond Jones,
1427 Eye St. N. W.,
Washington, D. C.

Applicant: Cranford P. Walker
Ser. No. 296,781
Filed Sept. 25, 1939
For Method of Measuring Location of Obstructions in Deep Wells

Defendant's Exhibit B—(Continued)

The amendment proposed has been entered under Rule 78.

CONWAY P. COE
Commissioner of Patents.

Rule 78 Jul 5 - 1940 Orders No. 2698, 2801, 3311.
B1192 7/B
U. S. Patent Office Jul 5 - 1940 Issue Division.
H. C.

In the United States Patent Office
Cranford P. Walker
Method of Measuring Location
of Obstruction in Deep Wells
Filed September 25, 1939
Serial No. 296,781

Washington, D. C., July 5, 1940

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Amendment Under Rule 78

Please amend the above-entitled application under the provisions of Rule 78 and without withdrawing the application from issue, as follows:

Claim 4, lines 8-9, change "lapse of time" to—time lapse—; lines 10-13, cancel "to thereby determine the . . . measuring the lapse of time" and insert—comparing with said time lapse the time lapse—.

Please enter new claim 9 as follows:

Defendant's Exhibit B—(Continued)

B1

9. The method of determining the distance to an unknown location of an obstruction in a well having a casing with tubing therein restricting the volume of the annular space within the casing and having another obstruction therein at a known location, which consists in creating at some known point within the casing an impulse to produce echoes from said obstructions distinguishable from each other, sequentially registering the impulse and the echoes from said obstructions in spaced relation to each other, and determining the distance to the unknown obstruction from said known point of impulse by comparing the elapsed time between the registrations of the impulse and the echo from the known obstruction with the elapsed time between the registrations of the impulse and the echo from the unknown obstruction.

REMARKS

This amendment has been made to render claim 4 more definite. The clause "to thereby determine the velocity, etc." is functional and does not follow from the elements that are preceding. This claim was also incomplete in that merely observing one time lapse and measuring another time lapse does not point out the invention. As amended, the claim recites definitely that the distance to the unknown obstruction is determined by comparing one time lapse with the other.

Defendant's Exhibit B—(Continued)

This claim has not been broadened and will require no additional search and amendments should be enterable under Rule 78.

Claim 9 is narrower than claims 4 and 6, for example, but is more definite and complete in that this claim clearly sets forth that the impulse and echoes are sequentially registered whereby the location of the unknown obstruction may be determined by comparing the time lapse between the impulse and the second echo from the unknown obstruction. It is deemed necessary to enter this claim to more specifically and more definitely point out the invention.

It is obvious that claim 9 is also narrower than claims already allowed and that no further search is necessary.

Respectfully submitted,

H. W. MATTINGLY

Attorney for Applicant.

Entry recommended under rule 78.

C. W. ROBINSON,

Examiner.

Entry approved

HENRY VAN ARSDALE

Acting Commissioner of Patents.

Defendant's Exhibit B—(Continued)

Div. 5 Room 3077
Address only
"The Commissioner of Patents,
Washington, D. C."
and not any official by name
Paper No. 8
All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant
Mailed Jul 10 1940.

Department of Commerce
United States Patent Office
Washington

July 6, 1940

Raymond Jones,
1427 Eye St., N. W.,
Washington, D. C.

Applicant: Cranford P. Walker
Ser. No. 296,781
Filed Sept. 25, 1939
For Method of Measuring
Location of Obstructions
in deep wells.

The amendment proposed has been entered under Rule 78.

CONWAY P. COE
Commissioner of Patents.

Defendant's Exhibit B—(Continued)

[Printer's Note: Copy of Patent No. 2,209,944, issued to C. P. Walker, entitled "Method of Measuring Location of Obstructions in Deep Wells," appearing here, is not reproduced, as it is identical with Plaintiff's Exhibit No. 3, which is printed in this Book of Exhibits.]

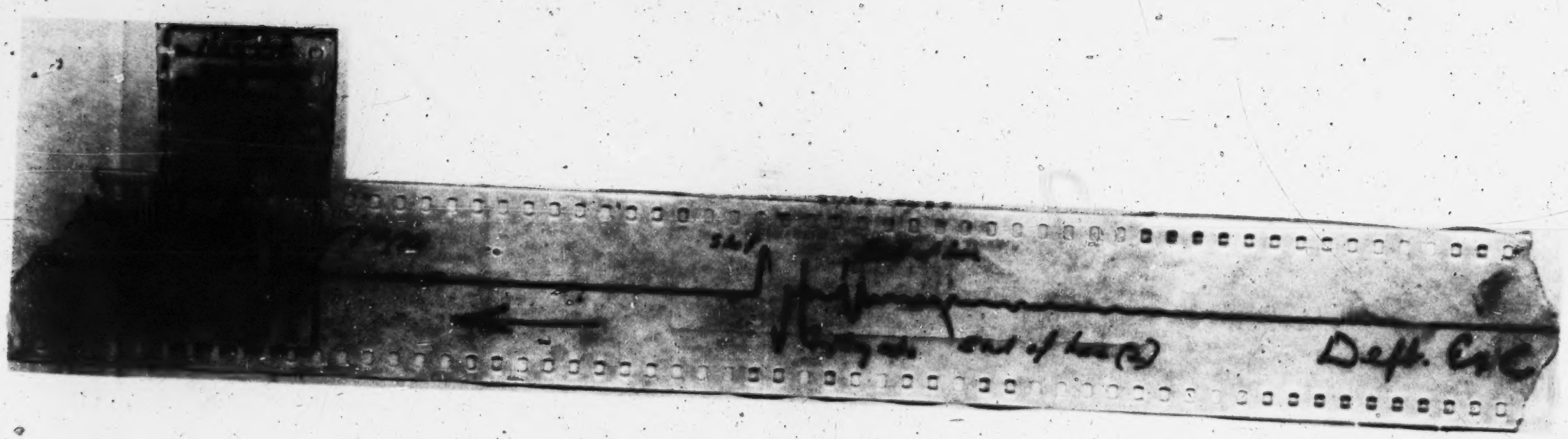
421

1939

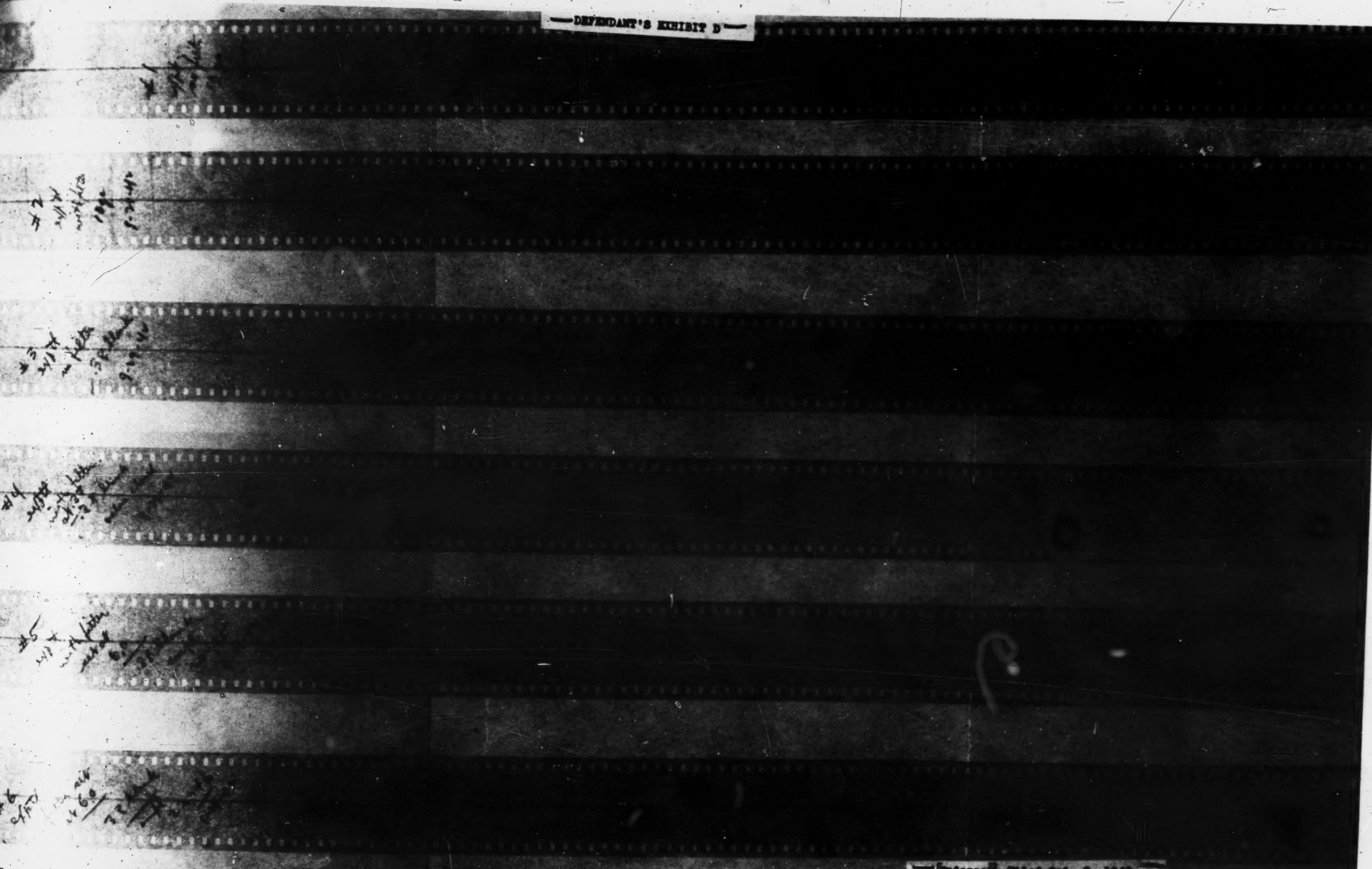
Contents

1. Application.....papers.
2. Print Oct. 2/39
3. Title Report Oct. 25/39
4. Assoc. Power of Attorney May 15/40
5. Pet. (R-78) & Amdt. A May 15/40
6. Letter (Aprvd.) May 16/40
7. Amdt. B (Rl 78) July 5/40
8. Letter (Rl 78) July 6/40

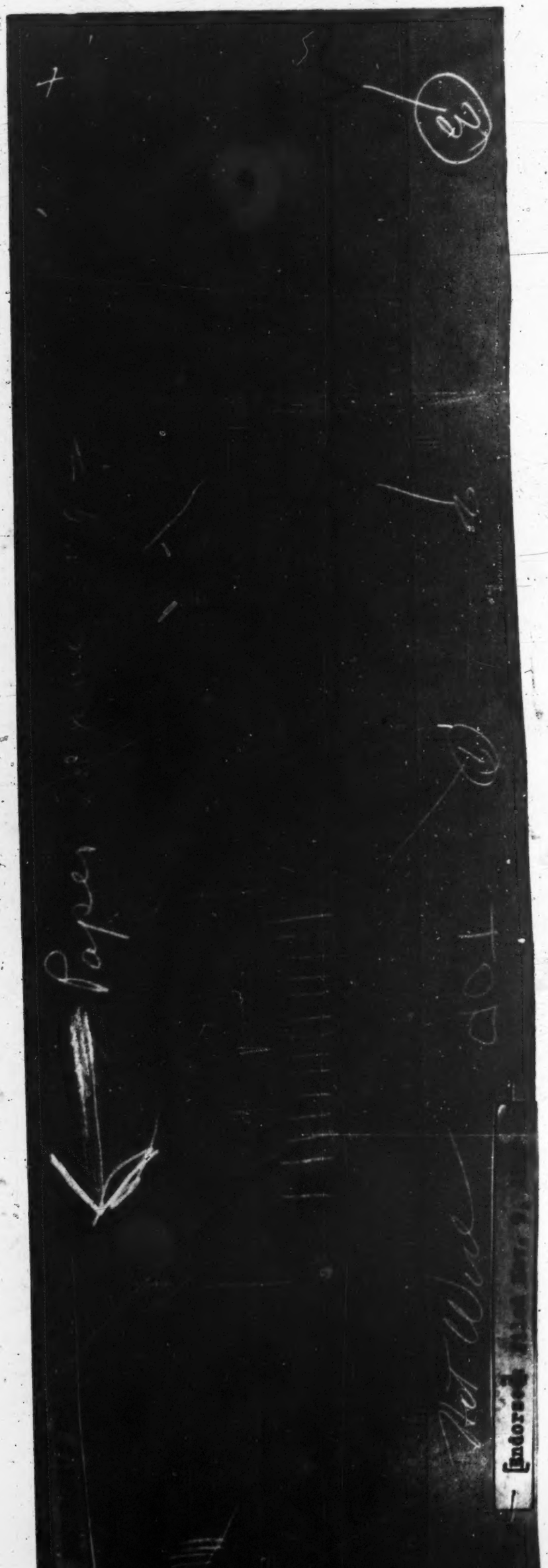
[Endorsed]: Filed Oct. 7, 1942.

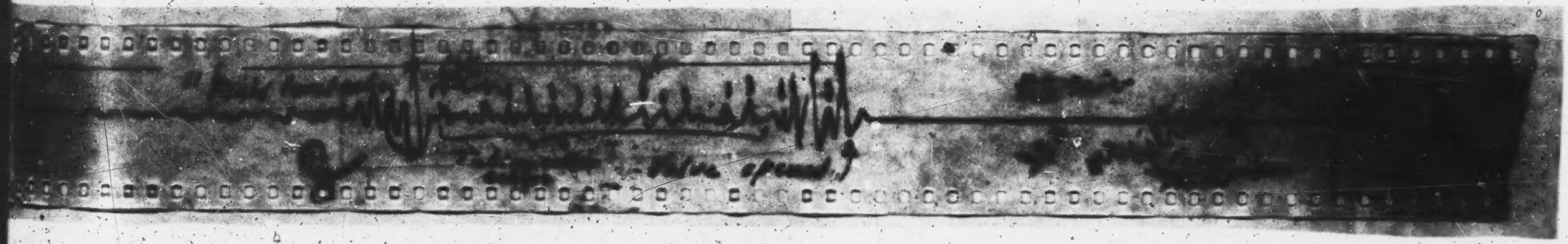

Depth Gage

—DEFENDANT'S EXHIBIT D—

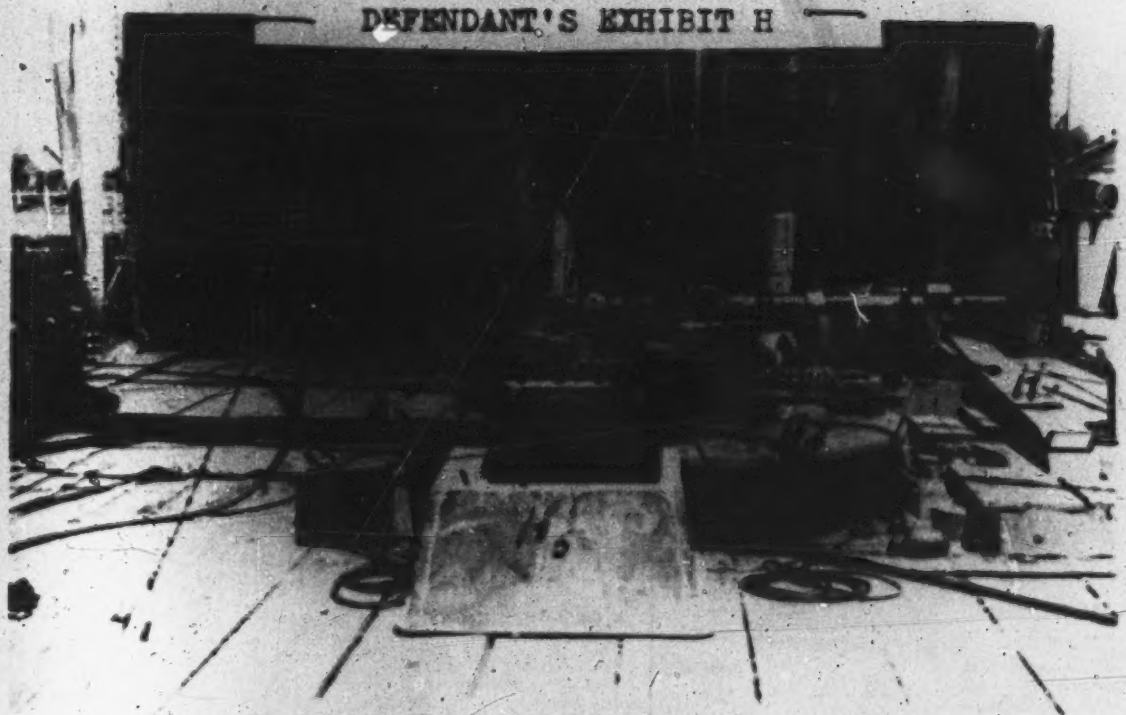


—Endorsed Filed Oct. 8, 1948—


Endorsed



DEFENDANT'S EXHIBIT H



[Endorsed]: Filed Nov. 2, 1942.

DEFENDANT'S EXHIBIT I

Endorsed: Filed Nov. 2, 1942.

DEFENDANT'S EXHIBIT J

[Endorsed]: Filed Nov. 2, 1942.

A Method for Determining Production Allowances in Prorated Fields

H. D. White, Jr.,* and T. V. Moore*

ABSTRACT

In this paper a method for determining equitable allowable production for wells in prorated fields is presented. The system is based upon the pressure drop in the producing sand observed by the flow of oil in the bore of the well, and is offered as a substitute for the "potential production" determined by open-flow tests. The data required may be taken at low rates of flow, and the results do not depend upon the type of equipment in the well. A numerical illustration is given to show the application of this method.

INTRODUCTION

[illegible]

[redacted]

ulate may be read directly from the curve. The difference between rock pressure and the bottom-hole pressure at any given production rate is the pressure-drop in the sand required to maintain that production rate. The plot of all productions secured with a given pressure-drop in the sand under widely different wells. The character of the sand, its porosity, permeability, and thickness, the extent to which it is saturated with oil, the physical properties of the oil, and the quantity of free gas which is associated with the oil are the important factors which control the pressure-drop in the sand for a given rate of flow. Porosity and sand thickness, by controlling the area of the pore spaces through which oil may flow, fix the linear velocity which must be established to maintain a given rate of production. Permeability depends upon the character, or average, diameter of these pore spaces and, hence, controls the pressure-gradient which is required to maintain a certain velocity of flow. The physical properties of the oil (especially viscosity) influence pressure losses in a similar manner. Large quantities of free gas flowing in the wells sand, of course, occupy a considerable portion of the space between the sand grains, thus reducing the void space through which oil may flow. This effect probably influences the pressure losses.

The amount of oil underlying a given property is directly proportional to sand thickness, porosity, and saturation. The amount of this oil which can be recovered depends upon permeability, the conditions existing in the reservoir (such as pressure and temperature), and the nature of the oil. As was shown previously, these same factors affect in a comparable manner the rate at which oil can be produced with a given pressure-drop. Thus, the production rate at a given pressure-drop should be a good index of the recoverable oil under a property.

If open-flow rate resulted in the same bottom-hole pressures in all wells in a field, the open-flow production could be used as an index of the productivity of a property. Unfortunately, the bottom-hole pressure at open flow is markedly influenced by the back pressure of the well head and the pressure-drop in the flow string. The back pressure at the well head even under open flow is not zero, but depends upon the size and length of the flow line and the location of the separator. The pressure drop in the flow string depends upon the depth of the well, the size of the tubing or casing through which the oil is produced to the surface, the gas-oil ratio, and the production rate. By changing the design of the flow string and the surface conditions, the bottom-hole pressure at open flow will consequently, the potential production, can be varied over a wide range. Furthermore, if the test covers only a short period, the open-flow may be affected by the history of the well immediately before the test. For these reasons, open-flow tests are not comparable and do not furnish a true measure of the capacity of the various wells to produce oil.

It is obvious that a true measure of the rate at which wells are capable of producing oil must depend on the character of the producing formation and on the conditions under which the flow occurs. The latter factors are controllable, and happens to be in the well. Should be based upon its ultimate production under the conditions imposed by production. It is, therefore, clear that some method of measuring the ability of a well to produce oil which is dependent only upon the nature of the sand and the conditions existing therein, and for which can be obtained values comparable to producing rates of flow. If the new method is to be used in a field already under production, practical considerations require that allowances distributed according to the new method should not differ widely from those distributed under the existing method.

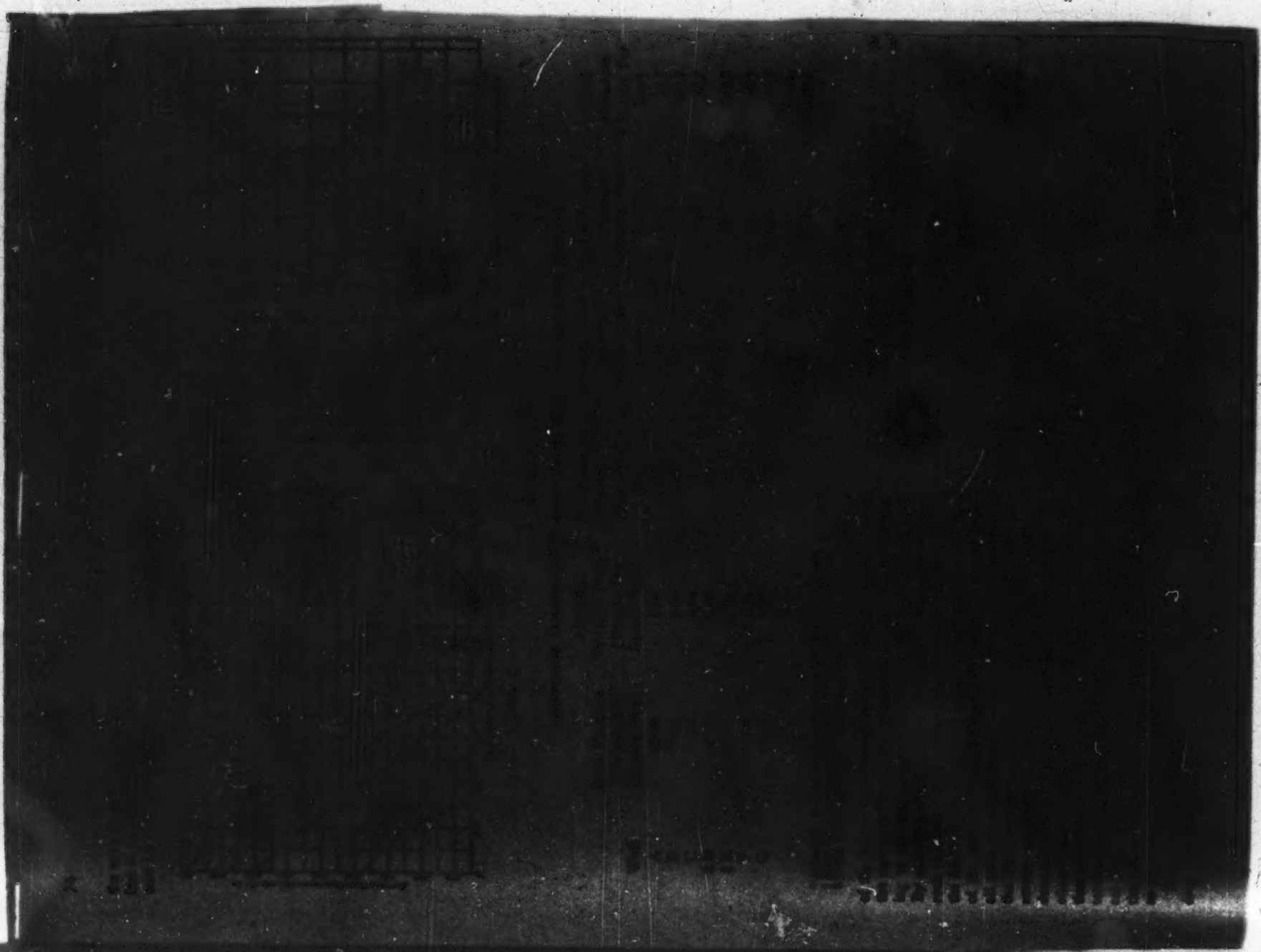
PROPOSED METHOD

The method proposed in this paper is a dual method, based on both acreage and capacity of the individual wells to produce oil. The percentage of the total field production allotted on acreage may be set at any desirable value, but for purposes of illustration it will be assumed arbitrarily that 25 per cent is to be allotted on the acreage basis and 75 per cent on capacity basis. The details of the proposed method are as follows:

The field is divided into units of equal area. Twenty-five per cent of the total production is distributed equally among the various units. The remaining 75 per cent is distributed among the units in proportion to their capacity to produce oil. These capacity allowances for the individual units are determined from the curves showing the relation between bottom-hole pressure and production rate. Inasmuch as the pressure-differential in the sand is the driving force which causes the flow of oil in the well, an equitable method of distribution would allow all operators to produce oil under a driving force which is a certain percentage of total driving force available. Hence, for any given well, the allowance is the rate at which it can produce oil when the pressure-drop in the formation is a definite percentage of the rock pressure. This percentage is fixed for the entire field. On units having more than one well, the capacity allowance for the unit is the average of the capacity allowances of the various wells thereon. For units having more than one well, the allowance may be taken from a single well or distributed among the various wells in the unit, depending upon local conditions; but in no case shall the sum of the production from the various wells exceed the unit allowance. The percentage of the rock pressure used in determining the capacity allowances is so adjusted that the sum of the unit capacity allowances will be 75 per cent of the total production which it is desired to take from the field. The determination of the value of the percentage of rock pressure which will fix the total production at any required value may be accomplished by simple interpolation. A procedure which may be followed in this determination is outlined in the numerical illustration given below.

Numerical Illustration

In order to illustrate more clearly the application of the proposed system, the following example of its application to an hypothetical field is given. The data required to determine the relationship between bottom-hole pressure and production rate for each of the open-flow tests for the wells in the hypothetical field have already been taken as seven wells in West Texas. The curves showing these relationships are presented in Fig. 2. Let us assume that these seven wells constitute an entire field whose total production is to be 1,000 bbl. per day. Assume wells "D" and "E" to be in



If the outlet of the field is to be 1,000 bbl. per day, 770 bbl. are to be distributed in proportion to the average well potential. The allowance of each unit which is based on potential is the ratio of the average unit potential to the total potential, multiplied by the daily allowance which is to be distributed in proportion to the potential. Table 3 is a summary of the calculations involved in the distribution of these allowances upon the basis of the open-flow test.

TABLE 3

Allowances Distributed in Accordance with Method Using Open-Flow Test

Unit	Ratio Average Unit Potential to Total Potential	Unit Allowance on Potential (Barrels Per Day)	Unit Allowance on Average (Barrels Per Day)	Total Allowance (Barrels Per Day)
A	0.0705	53	41.7	94.7
B	0.0556	43	41.7	84.7
C	0.0539	42	41.7	83.7
D-E	0.1705	131	41.7	172.7
F	0.1065	79	41.7	120.7
G	0.1430	110	41.7	151.7
		770	250.2	1,020.2

In Table 4 is presented a comparison of the allowances by the various units as calculated on the basis of the open-flow tests and on the basis of potential heads at the time the outputs of 1,000 bbl. per day and 2,000 bbl. per day

TABLE 4

Comparison of Allowances

Unit	Open-Flow Test	Static Head Test	Open-Flow Test	Static Head Test
A	94.7			
B				
C				
D-E				
F				
G				

developed which may be run in the wells on wire lines. These instruments are, in general, of two types: those recording pressures continuously, in which a chart is moved by means of clock-work; and those in which maximum pressures only are registered. The former type have the great advantage of furnishing a record of bottom-hole pressures throughout the entire period of the test. However, because of the limitation imposed by the size of the clock-work, these instruments are usually too large to be run in wells equipped with small tubing. Successful maximum registering instruments have been built with outside dimensions as small as 1¼ in. These instruments, however, must be run each time the conditions in the well have changed, if the effect of pressure upon these conditions is to be studied. The development of such instruments is being carried forward, and while the case favors devices which incorporate the advantages of both types may be available.

Under favorable conditions, two runs per day under their determinations of bottom-hole pressure by a recording gage. If runs are available for a small and suppose the [illegible] through which these tests are run, this [illegible] runs who run the instruments from the [illegible] What can be done in these circumstances [illegible] run the tubing outside. The number of [illegible]

Disadvantages of Proposed System

However, in this proposed system there are [illegible] disadvantages:

1. The most important factor which [illegible] [illegible] application of this proposed method [illegible] and time involved in securing the [illegible] believed that, with proper organization [illegible] equipment, this difficulty can be [illegible]

2. A minor disadvantage is the [illegible] [illegible] in measuring the [illegible] will be serious only in the case of [illegible] in any instance these data [illegible] be taken more accurately [illegible]

In proposing that [illegible] can be determined by the [illegible] realize that [illegible] the flow of [illegible] solution [illegible] developed [illegible]

No. L.&S.-PH
Def. EXHIBIT No. K-2
MARKED 11-8-... 19...
By ...
DEPUTY CLERK

N...

Bottom-Hole Pressures

...

DETERMINATION of pressures existing within oil wells is of increasing importance to petroleum production engineers. The value of such measurements has been particularly emphasized by the publication of bottom-hole pressure data in the control of production in Yates Pool and by the attempts which are now being made to develop data which can be used for similar purposes in East Texas.

Application of Pressure Measurements

Measurements of this type promise to be of the greatest practical value as a means for determining the conditions existing within a producing formation. Although only a few of the possible applications have as yet been investigated and developed, it has been shown that considerable of great value can be obtained through measurements of bottom-hole pressures. The work which has been done emphasizes even more important future engineering developments. Three general classes of measurements of pressures within oil wells may be mentioned:

A. Measurements of pressures at the bottom of an oil well while it is shut down; that is, the equilibrium pressure of the producing formation when no oil is being withdrawn.

Measurements of this type may be applied to follow the rate of depletion of an oil field. Methods for doing this have been developed and described by the Texas Pool Engineering Committee,[1] and are now being applied in East Texas.[2] Of course, an intensive application of bottom-hole pressure data for this purpose involves the study of rate of water encroachment, and of solubility of dissolved gases. In conjunction with these factors, it is possible that data on bottom-hole pressures will lead to a very accurate picture of formation conditions. From values derived by engineering calculations, shut-down bottom-hole pressures are of great utility in studying rate of depletion of a field, and are a necessary part of any scheme of control which is based upon considerations of reservoir energy.

B. Measurements of bottom-hole pressures while wells are producing.

Measurements of this type, in conjunction with measurements of density and viscosity, make possible a direct determination of the effective permeability of a producing formation.[3] This has been proposed as the basis for an equitable schedule for operation and is determining the potential production of wells.[4] For many detailed

---

Appendix B of the present report is in the form of [illegible] by research engineers of the Texas Pool Engineering Committee. These reports are [illegible] Pool Engineering Committee, also [illegible] and W. H. Wood.

...data there are now available are extremely limited. This application can be made, but a direct question to [illegible] engineering deliberations.

...measurements of pressures throughout the length of a well [illegible] data will be obtained from such measurements. For example, measurements of pressures throughout the length of the casing of a well which is producing by natural flow or gas lift will develop data for a most accurate interpretation of the forces which [illegible] have possible. This will lead directly to improved drawing bits, and to more economical application of gas-lift methods.

Methods of Measuring Pressures Within Wells

The methods which are available for measuring pressures existing within wells have been thoroughly described by Millikan and Sidwell.[5] Besides the methods which have been used are:

A. Measuring hydrostatic pressure by displacing fluid from the casing with gas.

The gas pressure at the surface, plus a correction for the weight of the gas column, is equal to the pressure existing at the bottom of the casing. This is the most accurate method available, but is subject to certain disadvantages. The most important of these is the high cost and large size of the compressor equipment which must be used. In the long shut-in periods necessary for making measurements, and in the fact that such tests must necessarily be shut down while measurements are being made.

B. Bombs sealed with check valves and designed to bring to the surface samples under the pressure existing within a well have been widely used, particularly in West Texas.

Such bombs are very simple, but do not give accurate results. The main reason for this inaccuracy lies in the frequent disappearance of check valves; any simple valve which can be designed for this purpose will result in low readings of well pressure when the method is employed. Some inaccuracy is also induced by the volume of the casing head for determining pressures, by leaking of valves and connections, and by more or less complete [illegible] which are mixed with solubility of air and gas.

C. The bottom-hole recording gage is the most accurate and of the present time are known which other methods employing a recording gage, which remains in the well.

The check valves mentioned above will almost only one reading of a well. This gave additional gage [illegible] chart of pressures, and are controlled either by clock-work or other mechanism, to make possible a series of pressure readings at different points within the well on a single trip. Very valuable results have been obtained by the use of gage

sure gauges of this type, but they are, unfortunately and unavoidably, somewhat inaccurate. This inaccuracy results entirely from the impossibility of building an accurate gauge within the very small space which is available in an instrument which can be run through the tubing of an oil well. For practical purposes, the outside diameter of such an instrument cannot be more than two inches. A smaller outside diameter is highly desirable, since a bomb having a two-inch outside diameter cannot be satisfactorily used in a well while it is producing, because the flow of fluid will make it difficult to lower it through the tubing, and since the gauge will interfere with the flow through the tubing, and the pressures measured will be different from those existing before the gauge was placed in position. This limitation of size of the gauge elements, combined with the necessity for great ruggedness, makes it impossible to develop an instrument of this type which will read well pressures accurately. The scales are necessarily so small that precise reading is impossible, and the construction of the moving parts is such as to deprive the gauges of any great delicacy. Although but few figures are available to support such a statement, it is extremely likely that none of the pressures measured with bombs of this type, even when controlled by frequent calibration of the gauges, are accurate within five per cent.

D. *In fields where the bottom-hole pressure is sufficient to support a solid fluid column to the surface, it has been found possible to calculate shut-in bottom-hole pressures with a considerable degree of precision from the surface pressure and the average specific gravity of the fluid column.* A similar calculation can be applied in fields of lower pressure, provided the height of the standing fluid column can be accurately determined. This method is particularly applicable in East Texas and affords a simple and rapid means of following changes in bottom-hole pressure. However, the calculation cannot be made until the average specific gravity of the fluid column has been accurately determined by actual measurement of bottom-hole pressure. Further, the specific gravity will change as the average bottom-hole pressure of a field declines, and it will therefore be necessary to re-determine the constants at frequent intervals in order to insure the validity of the calculated values. Hence calculation, although its utility has been proven, is entirely dependent upon the use of measuring devices.

The new apparatus, which is described below is designed to eliminate as many as possible of the difficulties which have been experienced with other types of equipment for measurement of oil-well pressures. The requirements which it was intended to meet are:

a. The instrument should be capable of reading pressures at any point within the well, either flowing or shut-in, with a high degree of precision.

b. Readings should be rapid; that is, it should be possible to take a large number of readings, and to check the readings, on a single trip into the well.

To meet the requirements of precise reading, and to avoid the necessity of putting delicate and expensive measuring instruments into the well, it was decided to build an apparatus which would measure pressures by the first method listed above; that is, by balancing the pressure of a gas column against the well pressure at the point of measurement. To eliminate the necessity for heavy and expensive compressor equipment, and to make it possible to read pressures at any point of the tubing of the well, it was decided to use compressed gas out of cylinders for the measurement, and to introduce it into the well through an

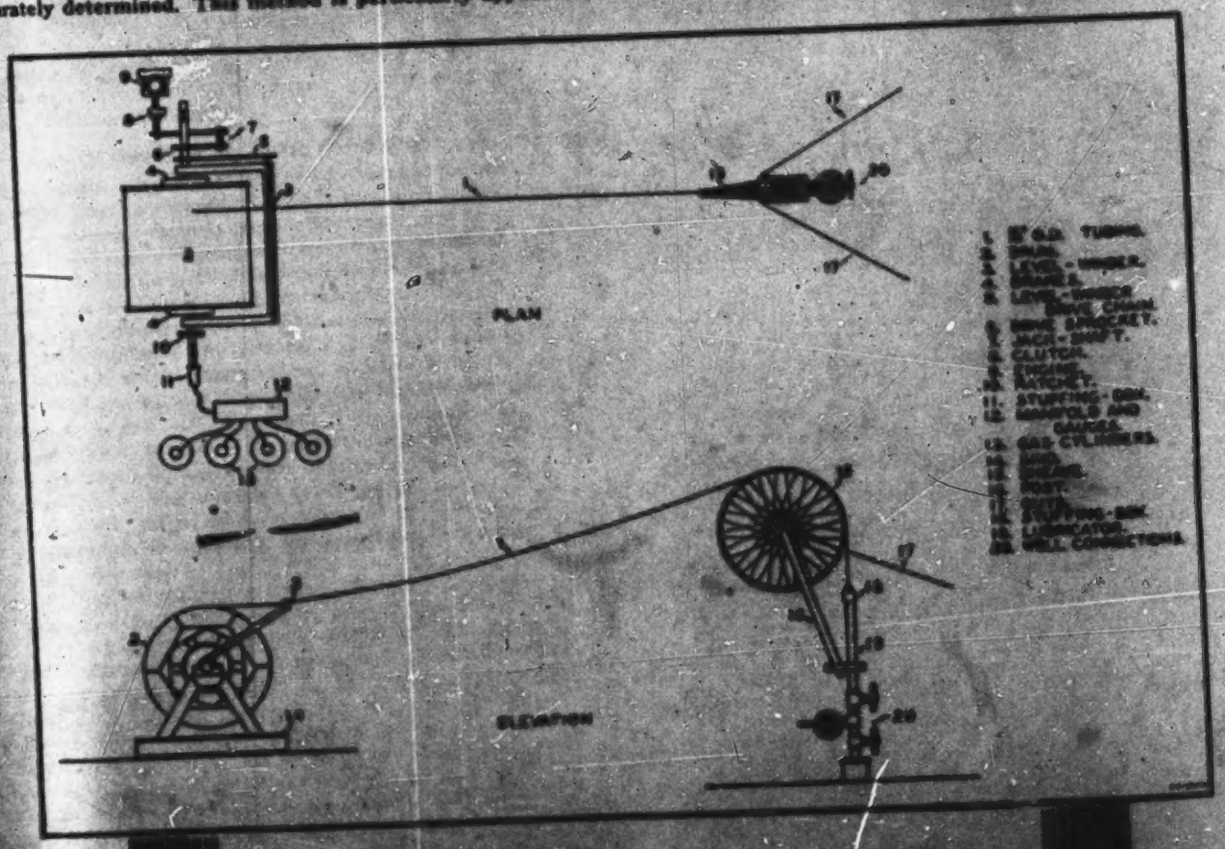


FIGURE 1—Diagram of typical bottom-hole pressure apparatus.

FIGURE 2—General view of apparatus mounted on trailer. Starting at the cab, this view shows the small gasoline engine used for hoisting the drum upon which the tubing is coiled, the box containing manifold and gauges, and four cylinders of hydrogen mounted in a rack.

extra string of small tubing. For economy of compressed gas, and to facilitate the handling of equipment, very small tubing was used.

General Features of "Gulf" Apparatus

The apparatus, as finally designed to meet these requirements, consist essentially of a continuous string of tubing, one-eighth inch outside diameter and one-sixteenth inch inside diameter, long enough to reach to the bottom of the wells measured, and handled into and out of the well by a special hoisting drum which is made of large diameter to avoid destructive bending of the small tubing. The bottom end of this tubing string carries a set of check valves, which are not essential to the operation of the apparatus, but which are carried as an added protection against the admission of fluid to the small tubing. In addition, the bottom end carries a pressure-tight well for a maximum registering thermometer. At the surface, the tubing is connected to the pressure gauge, and to cylinders of hydrogen gas which supply the pressure for equalizing the pressure within the well.

The method of making measurements is extremely simple and rapid. The tubing is run to the desired depth, and hydrogen is admitted from the cylinders. Hydrogen pressure is built up until it is considerably higher than the expected reading. The gas supply is then shut off, excess gas escapes from the open bottom end of the tubing, and the equilibrium pressure is read at the surface from the pressure gauge. Obviously, the only correction which need be applied to this reading is the weight of the hydrogen column within the tube, since the readings are made with a static gas column, and are not influenced by any friction factors. As soon as a reading is taken, hydrogen is again admitted, and the procedure repeated to obtain a check reading. In the work which has been done with this

FIGURE 3—Sheave and lubricator mounted on a well.

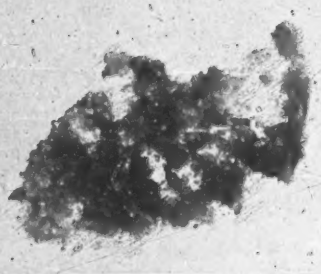


FIGURE 4—Stuffing-box end of tubing hoist shaft. 1. End of drum. 2. Brake drum. 3. Support for level-winder. 4. Ratchet. 5. Shaft. 6. High-pressure stuffing-box.

apparatus, it has been found easy to check bottom-hole pressure readings in East Texas within one or two pounds per square inch on repeated readings.

Details of Construction

The essential features of the construction of the apparatus are briefly described below. The equipment has been loaded upon a trailer, as shown in the illustration. So large a truck is not really essential, and was used merely to provide adequate space. The weight of the entire apparatus, including the four cylinders of gas and the gasoline engine which is used to drive the hoist, is less than 3000 pounds.

A. *Tubing.* The tubing string is of seamless steel, one-eighth inch outside diameter and one-sixteenth inch inside diameter, and 4000 feet in length. The tubing was produced in lengths of 40 to 50 feet, and was fusion welded into a continuous length at the plant of Howard Smith Company, under the supervision of Mr. Hillman D. Wilson, engineer for Howard Smith Company. The outside of each weld was filed smooth, and the weld was then subjected to test under a tensile load of 300 pounds. In view of the fact that the total weight of the 4000-foot string of tubing is only 125 pounds, it was felt that this test load was adequate. The welding required exceptional care and skill, and much credit is due to Mr. Wilson and Howard Smith Company for carrying out this work. In view of the difficulty of welding, and the possible danger of breakage at the welds, Gulf engineers plan to substitute a string of tubing of the same dimensions, but made of brass or bronze of high tensile strength. Tubing of this type can be obtained in very long lengths, and the number of joints in the tubing string correspondingly reduced.

B. *Bottom End.* The bottom end of the string of tubing is brazed into a short one-fourth inch pipe nipple. This screws into the bottom end, a sinker having a weight of 10 to 15 pounds. This bottom end carries a pressure-tight well for a maximum registering thermometer, and a pair of three-sixteenths inch ball check valves. These valves close off the bottom end of the tubing string, and are designed to make it possible to run the apparatus into a well without carrying gas pressure on the tubing. It is very important that fluid should be completely excluded from the small tubing; the check valves are not absolutely certain, and for this reason it has been found advisable to carry gas pressure into the tubing while it is being run into the well, as an added precaution against the admission of fluid. The present bottom end has an outside diameter of 1¼ inch, but plans have been made for one having an outside diameter of three-fourths of an inch, which may be used inside one-inch or 1¼ inch tubing.

C. *Tubing hoist.* The 4000-foot length of tubing is coiled in a single layer upon a drum four feet in diameter and four feet long. The drum is made of wood, which is covered with heavy duck, treated with airplane dope. The drum is carried by angle iron spokes, on a 2 3/16-inch shaft. On each end of the drum is mounted a heavy automobile brake drum and brake. The shaft also carries a heavy ratchet and pawl, which are engaged in pulling the tubing from the well, and prevent dropping the tubing, if anything goes wrong with the hoisting equipment. The shaft also carries a "level-winding" mechanism which guides the tubing onto the drum. A drive sprocket is attached to the shaft with a breaking-pin, which is proportioned to shear off if the load on the tubing exceeds 250 pounds. This is a safety precaution, to prevent pulling the tubing in two if it should catch. From the drive sprocket, drive chains pass through a jack-shaft and clutch to a five horsepower gasoline engine which provides power for hoisting. Hoisting power could equally well be provided by a power take-off on the truck; but the engine was used for greater portability and flexibility. All of the

FIGURE 5—Views of tubing, showing two welds and end view. Approximately actual size.

FIGURE 6.—Lubricator, swivel elbow, and valve for one of the gauges.

mechanism, including the engine, is mounted on

Operator at well head. From the drum of the tubing which is placed not less than 75 or 100 feet from the the tubing passes over a sheave four feet in diameter mounted over the casing head. The sheave is of ht construction, having a deeply grooved steel rim carried on a hub and axis from the front wheel otorcycle on motorcycle spokes, which were cut o the necessary length by welding. The sheave is d from a section of pipe which is mounted as a r on the casing head, and is also guyed to hold ately in position. The tubing passes from the through a stuffing box on the top of the lubricator Valves on the Christmas-tree are used in lubricat- bottom end into the well tubing.

connections. The upper end of the one-eighth-inch brazed into a one-fourth-inch pipe nipple, which is with a high pressure union to a nipple which is nto the shaft of the tubing hoist. A hole is drilled e axis of this shaft to one end, on which is a high-pressure stuffing box of special design. ffing box, which works on the principle of packing ras against grease carried in a ground joint and packing gland, has been found to be perfectly ainst from 1500 to 1800 pounds per square inch sure. From the stuffing box connection is made as manifold.

manifold. The gas manifold is made up of one- ch hydraulic pipe and one-fourth-inch—3000-pounds needle valves. The main gauge, which is used for urement of well pressures, is a 12-inch—3000 pound ydraulic gauge. This gauge has been fitted with scale reading directly to 10 pounds per square permitting accurate estimation to one or two er square inch, since each 10 pound division of the a length of more than one-eighth of an inch. The of course, periodically calibrated against a dead ester, and the manifold also carries connection for auge, with which the calibration of the working periodically checked. The manifold carries in- gauges and valves for four hydrogen cylinders.

Publishing Company Publication

Correction for Weight of Gas Column

When measurements of well pressures are made with this apparatus, it is necessary to add to the pressure measured by the gauge a correction for the weight of the column of gas within the small tubing. This correction is of course small, and is in fact less than the errors which are present in measurements made by other methods. However, the correction for the weight of the gas column is very simply made, and is necessary for the accurate determination of well pressures.

The exact bottom-hole pressure may be calculated from the measured values by the use of the following formula:

$$P_b = P_m + \left[\left(\frac{.00559}{144}\right)(D)\left(\frac{P_b + P_m}{2 \times 14.7}\right)\left(\frac{460}{460+T}\right)\right]$$

or, in simplified form

$$P_b = P_m + \left[\left(.00007\right)(D)\left(\frac{P_b + P_m}{460+T}\right)\right]$$

where

P_b = the actual pressure at the bottom of the string of ¼" tubing, in pounds / sq. in., absolute.

P_m = the pressure measured by the gauge at the surface, pounds / sq. in., absolute.

D = the depth at which the measurement was made, in feet.

T = the average temperature of the gas column, in degrees Fahrenheit.

The constant, .00559, is the weight of one cubic foot of hydrogen gas at 0° F., under a pressure of 14.7 pounds per square inch absolute.

This complete formula need seldom be used, since it provides a correction far more precise than that obtainable by measurement. The only case in which the correction need be calculated by this complete formula is where the pressures measured are extremely low, and where the highest precision is required.

For all ordinary purposes, a sufficiently precise approximation can be expressed in a far similar formula, as follows:

$$P_b = P_m \left[\left(.001214\right)(D)\left(\frac{P_m}{460+T}\right)\right]$$

This approximation is made by calculating the pressure of the gas within the string of one-eighth-inch tubing, as equal to the pressure measured at the surface, rather than as an average between the measured pressure and the

actual pressure at the bottom of the string. The error induced by this assumption is entirely negligible. It is also possible to make a valid calculation on the basis of a somewhat rough estimation of temperature; for example, an error of 50° F. in temperature of the gas column would result in an error of only one pound per square inch in a measurement of bottom-hole pressures under conditions at present prevailing in East Texas.

Auxiliary Equipment

The design of the apparatus is such as to make possible the use of auxiliary devices for obtaining additional information on well conditions.

Although no work has as yet been done in the field along these lines, apparatus has been developed for securing samples of well fluids under the exact conditions existing within the well, and for a very accurate determination of the specific gravity of the fluid at any point within the well. Both of these devices will make it possible to secure valuable engineering data.

Summary

Use of the Gulf bottom-hole pressure apparatus in the East Texas field has shown it to be extremely accurate and satisfactory. The few difficulties which have been experienced have been readily overcome, and are not at all basic.

FIGURE 7—Level Winder.

The great advantages of the apparatus lie in the precision of the measurements, in the fact that no intricate or expensive parts are placed inside of the wells, and in the possibility of making accurate readings at any point within a well, equipped with tubing of any size, whether shut-down or flowing, and of making any desired number of such measurements on a single trip into the well.

It is not believed that the apparatus should be applied for a day-by-day checking up of bottom-hole pressures within a field. In almost any area where frequent measurement of pressures is necessary, it is possible to develop some simple means for routine check-up, provided accurate equipment is available for a periodical calibration of the routine method. For example, tests made with the apparatus described in this paper have shown that bottom-hole pressures in East Texas can be very precisely determined from the top-hole pressure and the weight of the column of fluid within the tubing. Of course, precise measurement of bottom-hole pressures are necessary for the development of such a method, since only thus can the weight of the fluid column be accurately determined. For the East Texas field it has been found that a periodical check-up and re-determination of the weight of the fluid column by the use of the precision apparatus will make possible a very accurate and inexpensive determination of bottom-hole pressures from pressures at the tops of the tubing strings.

The apparatus described makes simple and practical measurements which have not hitherto been available, and is expected to develop data which will prove of great value to the petroleum production engineer.

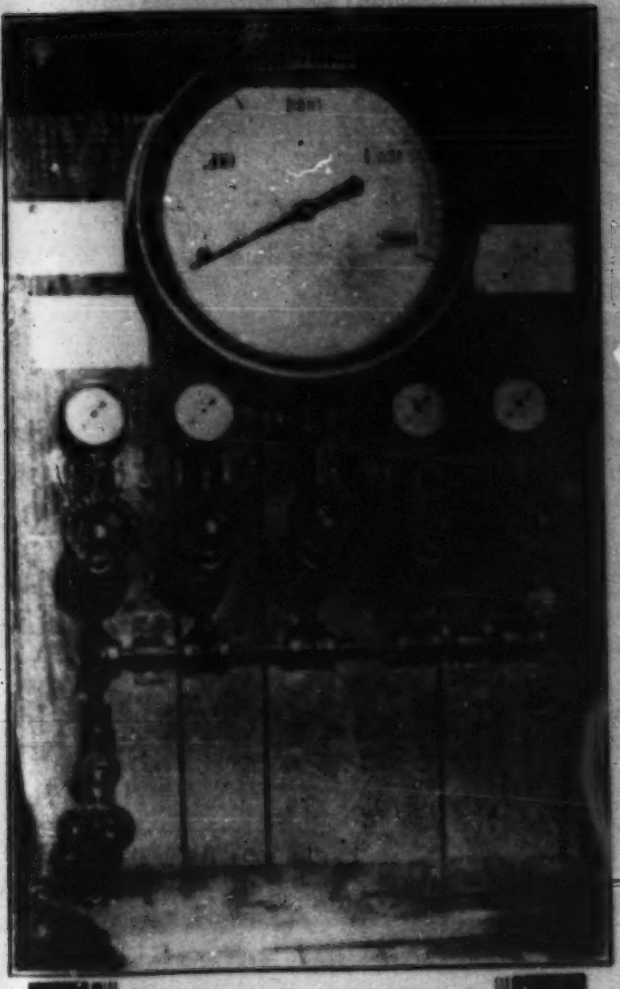


FIGURE 8—Gas Manifold and Gauges.

BIBLIOGRAPHY

[1] Oil & Gas Journal 30, June 18, 1931, page 14.

[2] Vance & Fagin, Oil & Gas Journal 30, October 21, 1931, page 32.

[3] McWilliams, paper presented before A.I.M.M.E., abstracted by Lane, Int. Pet. Tech., Vol. 3, March, 1931, page 14; April, 1931, page 127; May, 1931, page 208.

[4] Schuster, Pet. Eng. Vol. 3, January, 1931, page 26; February, 1931, page 31; April, 1931, page 90.

[5] Wilde & Moore, paper presented at Mid-year 1931 meeting A.P.I.; Oil Weekly 61, June 1, 1931, page 26.

[6] Millikan & Sidwell, Oil Weekly 61, May 11, 1931, page 21; also Pet. Eng. 3, May, 1931, and Int. Pet. Tech. Vol. 3, May, 1931.

Subsurface Pressures in Oil Wells and Their Field of Application

By D. G. [illegible],* Tulsa, Okla.

(Trans. City Meeting, October, [illegible])

[illegible] interest shown during the past year in the study of [illegible] reference to its early development. [illegible] to set an exact date when constructive thinking [illegible] evidence is available that thought [illegible] in the [illegible] 16 or 17 years ago. There is [illegible] of actual subsurface tests made by [illegible] of the Pennsylvania fields in 1918 and 1919.† These [illegible] with studies made on wells produced [illegible] the final outcome of the work led to the [illegible] which is reputed to have [illegible]. From this time on to 1927 a [illegible] were made with make- [illegible] but probably not until 1927 was [illegible] directed to the subject.

[illegible] of the Pennsylvania Division four years ago was [illegible] to this country written for the [illegible] value and importance of subsurface pres- [illegible] to have been the first to present direct [illegible] through the use of a specially [illegible] be expected, the instrument [illegible] results were obtained and, to [illegible] a progressive step in the right direction. [illegible] in 1931, many noteworthy improvements [illegible] and perfection of subsurface pressure instruments [illegible] all randomness. Because of the magnitude of this task [illegible] the men who pioneered this work. They should feel a [illegible] in the thought that their efforts have paved the way for the construction of this most valuable study.

At the present time more than a dozen companies are operating sub- surface pressure instruments in the Mid-Continent field. Engineers in

* Production Engineer, Beardsall Oil Co.

† Text performed by J. T. Hayward, Romanian Consolidated Oil Fields, Ltd.

‡ K. C. Schafer and B. R. Stephenson: Measurement of Original Pressure, Temperature and One-oil Ratio in Oil Sands. Trans. A.I.M.E., ([illegible]) [illegible], Petr. Dev. and Tech., 118.

[redacted]

another therefore cases in which it is impractical, if not impossible, to run the [illegible] pressure bomb. However, there are many instances where the surface pressure holds no relation to the bottom-hole pressure and accurate calculation of such a pressure is impossible. It may be, therefore, of value in clarifying the problem to draw up a few "rules and regulations" whereby one may be reasonably guided in his interpretations of surface pressures.

Rules and Regulations

To facilitate satisfactory understanding and ease of explanation it will be convenient to divide all wells into two classes, as follows: (*A*) Wells in which all gas is in solution at the bottom of the hole, such as wells in the East Texas field, and in which the head of oil is sustained purely through hydrostatic pressure. Further, for the sake of convenience, let us call such a well, whose pressure is more than sufficient to maintain a solid column of fluid to the top of the hole, an artesian well, and one whose pressure will maintain only a partial column, a semiartesian well. (*B*) All wells not included in *A* and in which free gas exists in the formation.

A

1. Bottom-hole flowing pressure cannot be accurately calculated on either an artesian or a semiartesian well due to continuously changing temperature and to the liberation of gas from solution.

2. The calculation of bottom-hole static pressure for semiartesian wells is impractical due to the necessity for making subsurface observations of fluid level each time a calculation is desired.

3. By taking a few simple precautions the bottom-hole static pressure in an artesian well can be easily calculated from the following formula:

$$P = D \times 0.4343 \times G + p$$

Where P is desired subsurface pressure.
D is depth of desired pressure.
G is flow column specific gravity of oil.
p is surface pressure.
K is 0.4343 (weight per foot of water).

The specific gravity of the oil within the flow column may be readily obtained from one single static gradient test with a pressure bomb. The calculation is simply the ratio of the pressure drop within the flow column per unit of length to the pressure drop or weight of an equal length column of water. An example of this calculation is shown in curve 1, Fig. 1.

4. To obtain accurate results, care must be taken regarding the temperature of the oil in the flow column. Preferably, no tests or observations should be made less than 24 hr. after the well has been flowed, thus giving the oil in the column a chance to reach stable earth temperature.

5. Precaution also must be taken in bleeding off the small pocket of gas which accumulates at the top of the hole. This must be done slowly so as not to decrease the pressure sufficiently to cause the gas to come out of solution and produce a frothy condition of the oil at the top of the flow column.

Wells in the East Texas field furnish a striking example of the application of this method of calculating bottom-hole or subsurface pressures. By closely observing the above directions, results under 0.5 per cent of error should be obtained.

B

1. To calculate static or shut-in pressure on wells of this type, in which free gas exists at the bottom of the hole, is usually impossible as conditions are virtually the same as in a "semiartesian well." Occasionally in wells with very high gas-oil ratio the formation pressure may be closely calculated due to the fact that on closing the well in pressure is built up so rapidly that no fluid head is allowed to accumulate. An illustration of this instance is shown in curve 1 of Fig. 5.

2. Unless a well of this type is tubed, the bottom-hole flowing pressure can in no way be reliably calculated. Acknowledgment is made to those men who have studied and are studying the derivation of formulas for calculating pressure drop in flow columns, but as yet it is believed the work is still in the experimental stage.

3. If it is certain that the fluid within the static column is depressed to the bottom of the tubing while the well is flowing, the bottom-hole pressure, or more correctly speaking, the pressure at the bottom of the tubing can be accurately calculated from either of the following formulas:

$$\text{Log}_{10} P = \frac{S \times Z}{122.62 \times T} + \text{Log}_{10} p.^{3}$$

Where P is bottom-hole pressure, absolute.

Z is depth of tubing inlet in feet.
S is specific gravity of gas.
T is absolute temperature of gas (t° F. + 460).
p is surface pressure, absolute.

$$P = p(e^{0.[illegible]} - 1) + p.^{4}$$

Where P is bottom-hole pressure, absolute.

p is surface pressure, absolute.
e is base of Nap. log (2.71[illegible]).
G is specific gravity of gas.
L is length of producing string.

(An average temperature of 60° F. is assumed.)

These formulas were derived for the purpose of calculating the weight of a static column of gas. A practical application of each of these formulas is shown in Fig. 5. The results are seen to check very closely with the pressure obtained at the corresponding depth from the pressure bomb.

4. It is impossible to mention here all of the cases where bottom-hole pressure on this type of well can or cannot be calculated from surface pressure. The greatest difficulty is probably encountered in making sure that the static column is completely filled with gas. Frequently, bridges of colloidal rotary mud or slugs of more or less permanent oil froth may be entrapped in the column. Also the position of the bottom of the tubing with respect to the point at which oil is entering the hole is of great importance. Undoubtedly, many other features enter into the problem and extreme precaution and good judgment must be exercised to insure correct application and results.

---

[3] Derived by Marion Dice, General Petroleum Corporation of California.

[4] Derived by Pierce and Rawlins. U.S. Bur. Mines, *Repts. of Investigations* No. [illegible], 9.

Subsurface Tests

Subsurface pressure tests in general may be divided into two classes, static tests and flowing tests. In either case pressure may be obtained at any point within the flow column to which a pressure bomb can be lowered, thus giving information from which curves, or pressure gradients, can be plotted; see Fig. 1, where curve 1 is the static pressure gradient, curve 2 is the flowing pressure gradient and curve 3 is obtained by plotting bottom-hole pressure against rate of production of the well during the test. This constitutes all the information in regard to pressure that is directly obtained in making a subsurface test. If desired, the bottom-hole temperature may be easily obtained by attaching a maximum recording thermometer to the bomb. A few pressure bombs are designed in such a manner as to give a continuous temperature record.

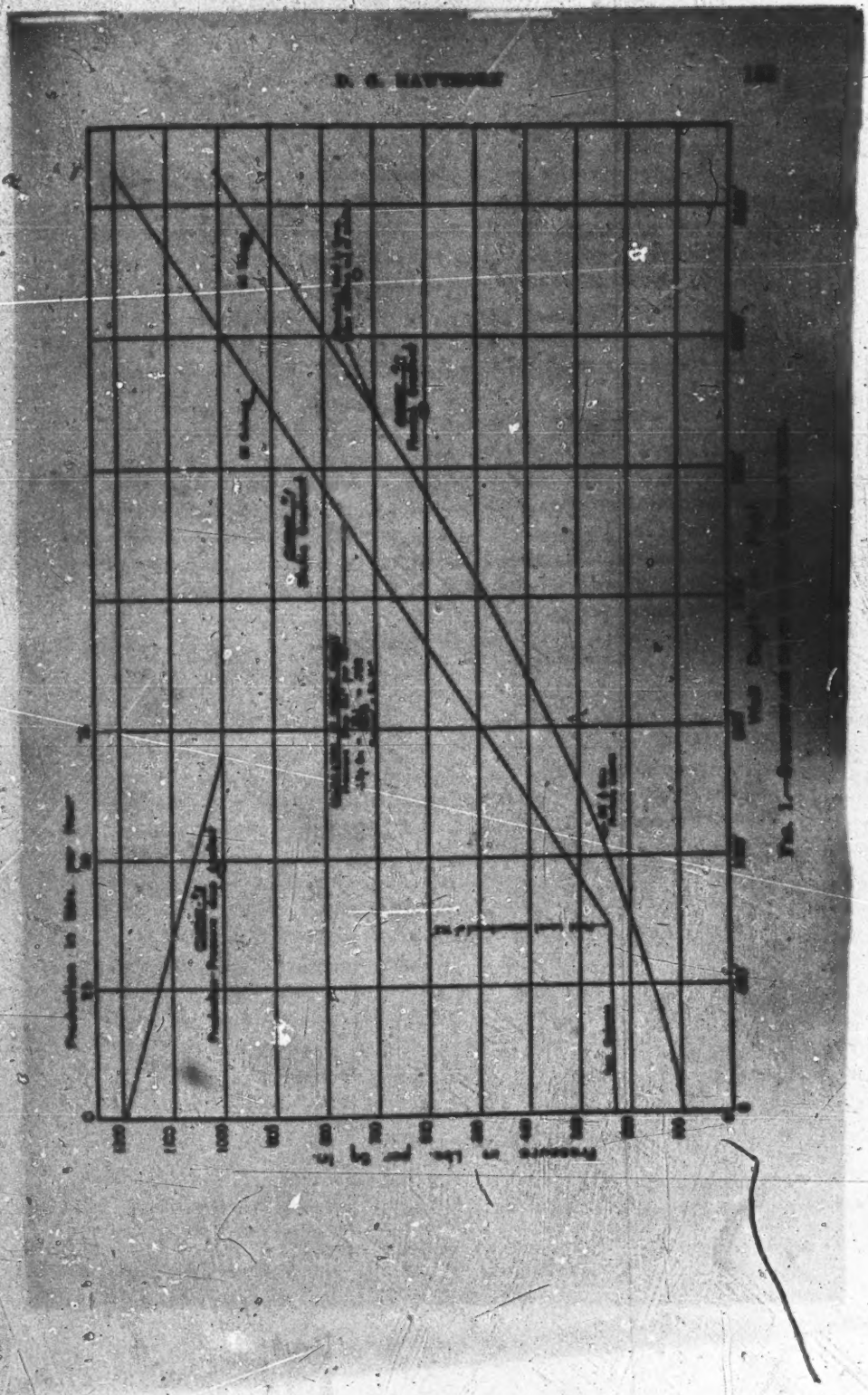
The importance of these data, simply through their obvious meagerness, has been greatly underestimated. The question is still frequently asked, "What information can bottom-hole pressures render other than total formation or reservoir pressures?" The value of subsurface pressure data, like many other classes of field information, lies not in the data but in the interpretation and application. A knowledge of subsurface pressures has long been the "missing link" in the chain of study relative to oil and gas flow in earth reservoirs and well bores. This information is now available and, as our fund of knowledge grows, subsurface pressures are destined to become the "nucleus" around which much practical and theoretical work will be centered and from which valuable interpretations will be made both in the field and in the laboratory.

Use and Application of Subsurface Pressures

The practical application of subsurface pressures embodies a great variety of problems. So extensive and complicated has the study of their application become that it is necessary, in order to obtain a comprehensive impression, to divide the subject into its component parts. The subject naturally separates itself into two main divisions: (1) the application to oil reservoirs and (2) the application to individual wells. The following discussions will be divided accordingly.

Application to Oil Reservoirs

Equitable proration and unitization during the past few years have been two of the foremost problems confronting the industry. In turn, both have presented and made necessary the solution of difficult problems of evaluation. In attacking these problems geologists and engineers have frequently found themselves with but a few facts and figures upon which to proceed. Subsurface pressures offer a new line of attack and furnish valuable and concrete information relative to existing conditions in reservoirs.



Formation Characteristics

Subsurface pressures and, more specifically bottom-hole flowing and static pressures, present valuable information relative to conditions and characteristics existing in the reservoir, information which heretofore could only be supplied in part by laboratory analysis. One of the most valuable contributions that bottom-hole pressures have to offer is the [illegible] "productivity factor."[1] This factor may be defined as "a [illegible] of the capacity of a well to produce." More specifically, it is the [illegible] which oil is produced from a well per unit of differential pressure.

$$\text{Productivity Factor} = \frac{\text{Rate of Production}}{\text{Differential Pressure}}$$

[illegible] as the value of this productivity factor directly depends on the [illegible] factors as permeability, i. e., porosity, saturation, texture, [illegible] the fluids, etc., it is also a measure of the permeability of the [illegible]. However, in order to render this measure of [illegible] of use it is necessary to reduce it to a work-[illegible] therefore:

$$\text{Permeability Factor} = \frac{\text{Productivity Factor}}{\text{Sand Penetration} \times K}$$

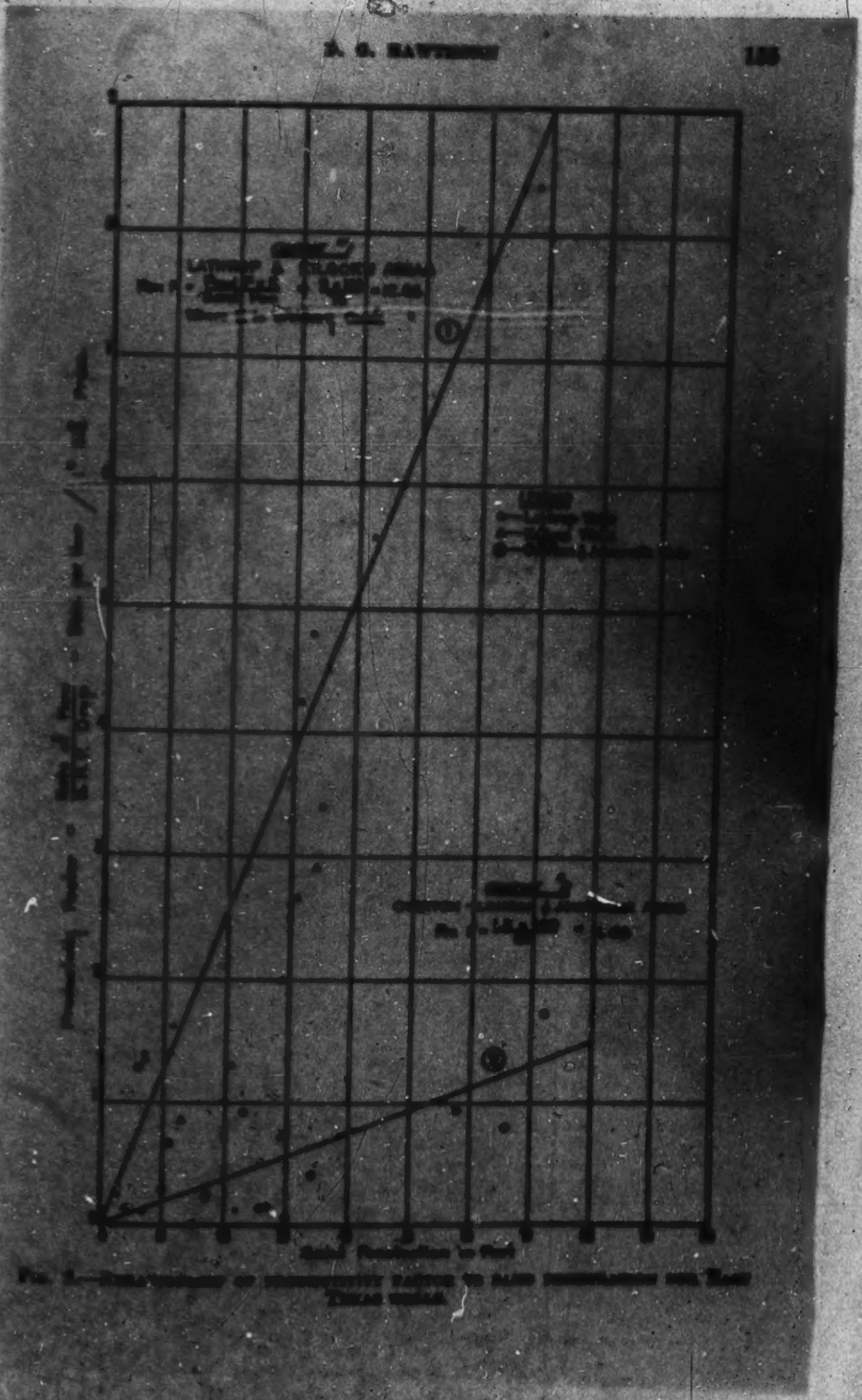
[illegible] depending on the diameter of the hole. Thus the [illegible] factor may be defined as the capacity of the reservoir [illegible] vicinity of a well to produce oil per unit of differential [illegible] per unit of formation penetrated. This furnishes a practical [illegible] which investigation of formation characteristics may [illegible].

[illegible] an analysis of [illegible] in the East Texas field. The [illegible] factor has been [illegible] against sand penetration for wells [illegible] parts of the field. [illegible] might be called a permeability chart [illegible] as the [illegible] the curves indicates the relative factor of [illegible] for the [illegible] districts. This factor is computed and [illegible] the chart. Considering the limited data at hand it is not desirable to make too literal an interpretation. Nevertheless, it is thought to [illegible] of actual conditions and is cited to illustrate a method of [illegible] reservoir characteristics in individual wells, leases or even [illegible] pool.

Ultimate Recovery

Attempts have been made to predict ultimate recovery from reservoirs [illegible] cumulative production against reservoir pressure and extend-

[1] [illegible] Wells and T. V. Moore: A Method for Determining Production Allowance in Natural Fields. A.P.I. Production Bull. 207, 71.



[illegible] IN OIL WELLS

[illegible] curve as a straight line. Little is known at present as to the [illegible] and trend of these pressure decline curves. The writer believes [illegible] will seldom, if ever, be a straight line. Arguments are pre-

FIG. 2.—[illegible] CONTOUR PLOTS OF THE EAST TEXAS FIELD. CONTOURED ON—[illegible]-FT. DATUM.

Data compiled through the cooperation of the following companies: Humble Oil & Refining Co., Gulf Production Co., Amerada Petroleum Corporation, Tidal Oil Co., Atlantic Oil & Production Co., Barnsdall Oil Co., Sun Oil Co., Shell Petroleum Corporation, Mid-Kansas Oil & Gas Co., Stanolind Oil & Gas Co., Sinclair-Prairie Oil Co. and Arkansas Fuel Oil Co.

sented to the effect that any method of evaluating ultimate recovery is essentially an estimate and that this "pressure drop method" should be as reliable as any other. The argument is further supported by the fact

field programme. However, the application of this method of estimating ultimate recovery from water-drive fields and especially one similar to East Texas, in which all gas is in solution in the reservoir, is unsound and without reason. It is impossible to predict the nature of pressure decline in such fields because at present no method is available for evaluating the pressure maintenance of a water drive on the differential pressure in the production wells. Further, there is no way in which to foretell the effect of gas energy on the reservoir pressure when such a pressure is reached that dissolved gas begins to come out of solution in the formation. Generally, common thought among engineers is that "Utopia" will be realized when such a time comes that water-drive fields are produced at such rate as to allow the water encroachment to keep pace with the withdrawal of extraction, thereby effecting and maintaining a constant reservoir pressure. If such thought is valid the estimated ultimate production under such conditions would be infinite, thus proving the failure of this method of estimating ultimate recovery from water-drive fields.

It is believed, however, entirely possible that sooner or later subsurface pressures will be used in estimating ultimate recovery from oil reservoirs. It should be possible, by correlating subsurface information to develop a method for analyzing and computing these data in such manner as to arrive at a reasonably close estimate of reserves. Like other methods, this of course would not be infallible. It should be particularly well adapted to natural flowing fields similar to East Texas in which the boundaries are defined early in the development. Further, it should be superior to other methods in that the subsurface pressure data would supply us for the first time with tangible information in which all the characteristics of reservoir characteristics would be reflected. The practical development and application of such a method should prove a valuable contribution to the study of reservoir capacities and ultimate production.

Reservoir Pressure Declines

A definite means for observing the nature and trend of reservoir pressure decline is rendered through the use of subsurface pressures. It has been previously brought out that no dependable relationship exists between reservoir pressure decline and the rate of extraction from a pool. Therefore, the only method for obtaining this information is through actual tests. If a sufficient number of tests are taken over a pool, pressure contour plats may be drawn.

Fig. 7 shows an assembly of several of these plats. If the area between corresponding contour lines on each of the plats is filled in with colors, each representing a different pressure area, it is possible to note at a glance the various changes taking place in the reservoir pressure. A

clear, detailed discussion of the use and interpretation of pressure contour maps has been given by H. D. Wilde, Jr.[4]

Bottom-hole Pressure Relative to Proration

Much has been written during the past year or two on the use of bottom-hole pressures as a guide for equitably prorating [illegible]. Nothing can be added to the subject in this short space [illegible] complicated subject in itself. Suffice to say that the [illegible] appear to have merit and the outcome of their practical application [illegible] awaited with interest.

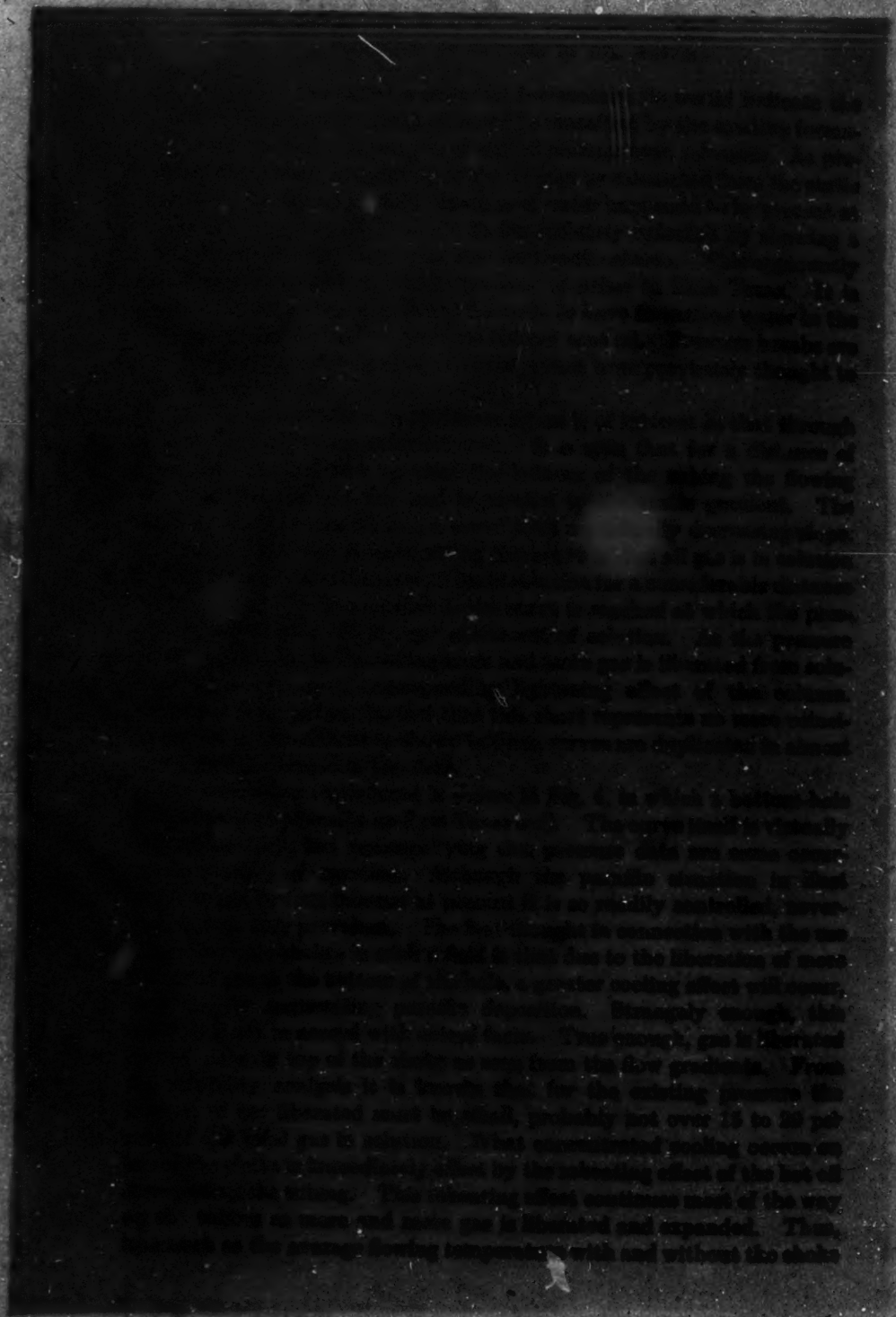
Application to Individual Wells

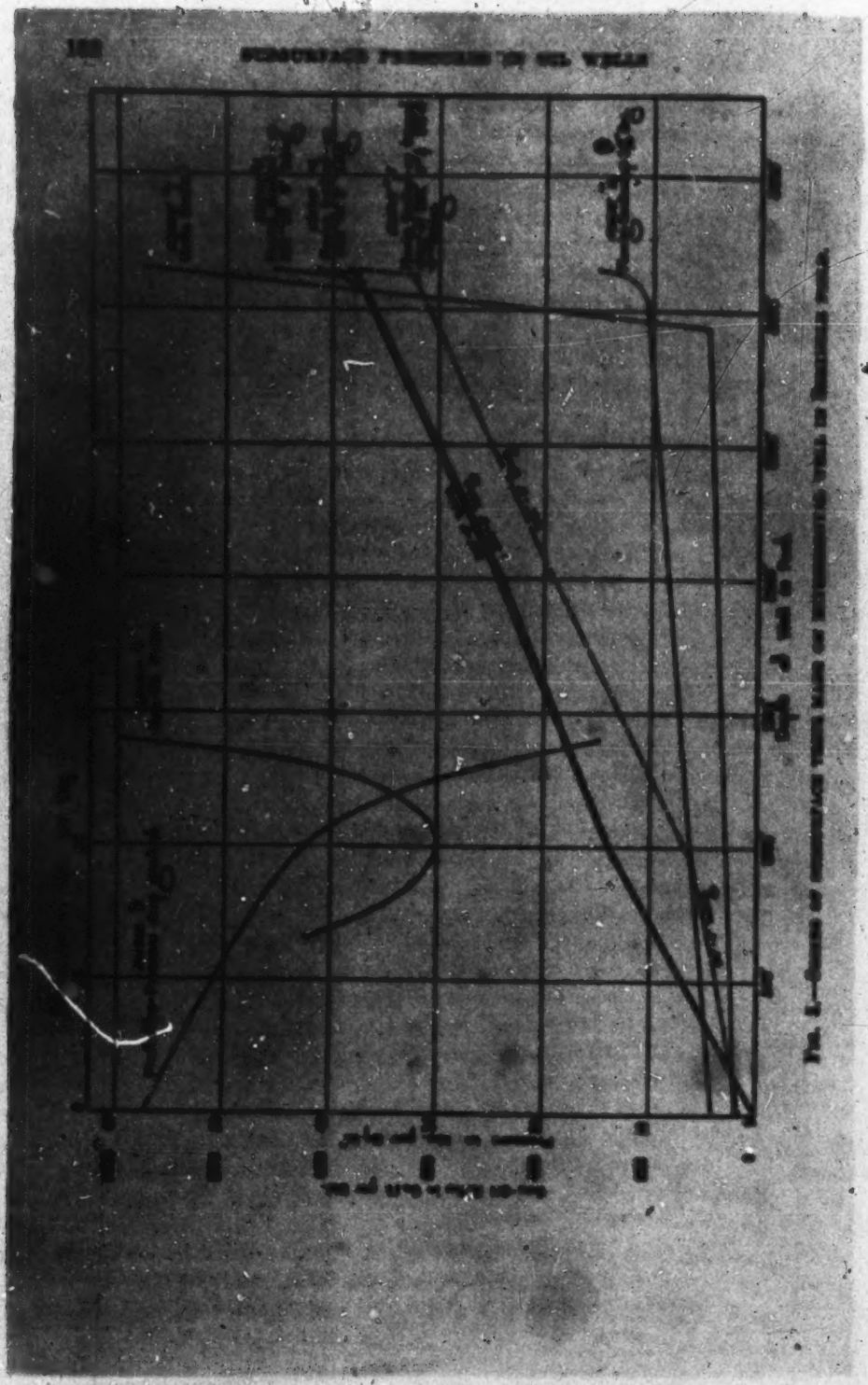
Considerable comment has been published on the [illegible] surface pressures to the study of oil reservoirs. As yet, [illegible] said relative to their application in studying the [illegible] dynamics of oil and gas flow in well bores. The [illegible] subject presents one of the most interesting possibilities [illegible] study and research in applying subsurface pressures. [illegible] attention from this work is probably due in part to [illegible] and also to the immediate need for all possible [illegible] relative to the problems of proration and [illegible]. [illegible] of application of subsurface pressures [illegible] method for analyzing and comparing formation [illegible] nal wells and losses is identical with that for [illegible] over, the study of pressures in flow columns is [illegible] remains within itself a distinct part of the subject [illegible] sure applications.

Undoubtedly, it has been noted that the pressures [illegible] reservoirs refer mostly to the bottom of the hole, [illegible] pressure, bottom-hole flowing pressure, differential pressure, [illegible] not the case for flow column studies since it is the [illegible] pressures from the top to the bottom of the hole and the [illegible] of pressure gradient curves that provide the significant [illegible] believed an examination into this field of application is [illegible] through a study of graphic representations of actual tests. [illegible] analysis of a few charts is made and the manner in which the [illegible] portray certain definite conditions is noted. It is [illegible] how directly and with what degree of certainty conclusions can be [illegible].

Fig. 1 illustrates an actual test performed on an East Texas well. [illegible] static gradient indicates the well to be of the [illegible] type, [illegible] much as the pressure is insufficient to raise the column of oil to the top of the hole. By projecting the static oil column gradient downwards, the

[4] H. D. Wilde, Jr.: Why Measure Bottom Hole Pressure? A.P.I. Mid-year Meeting, Tulsa, Okla., June 5, 1932.

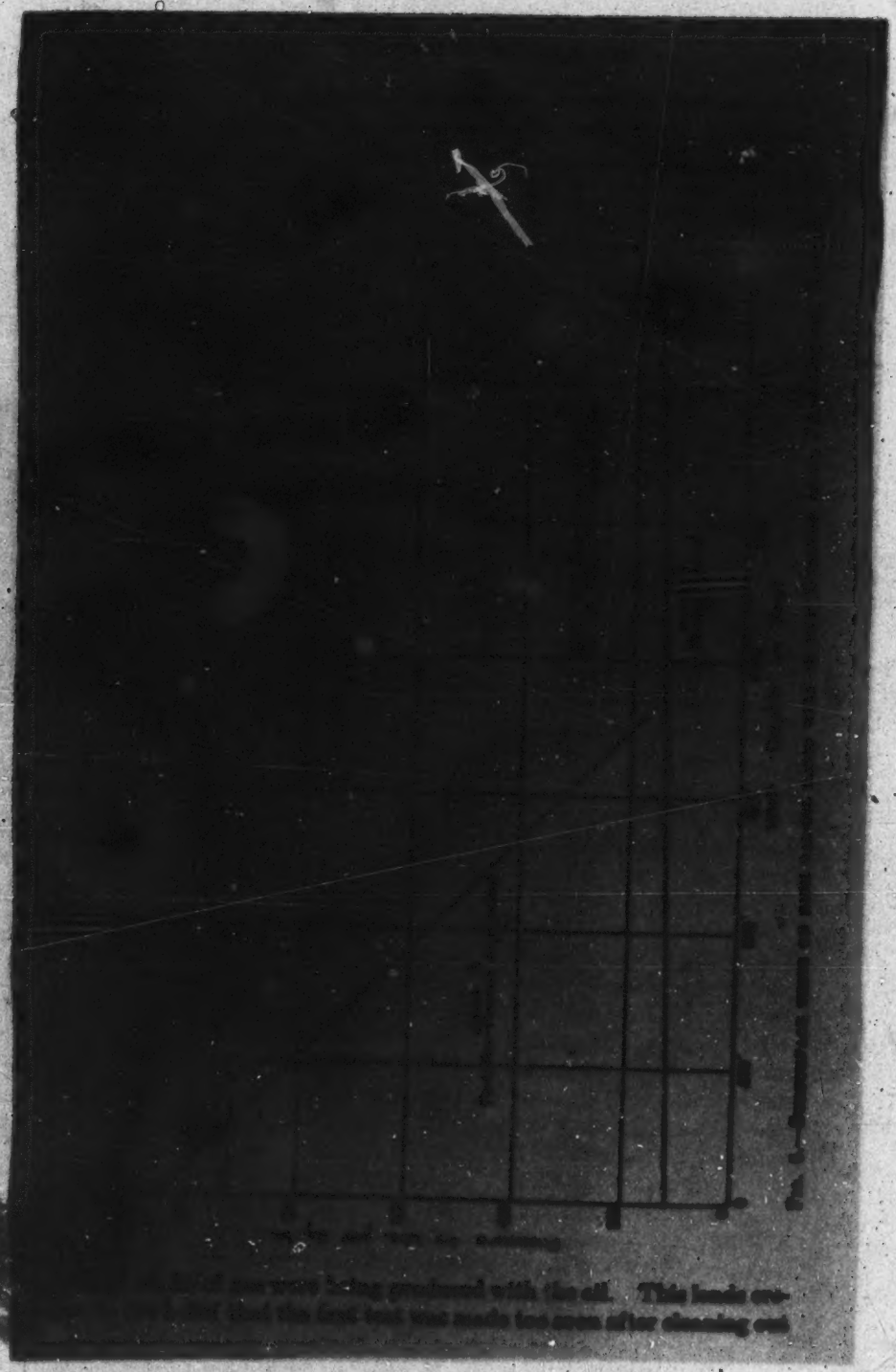


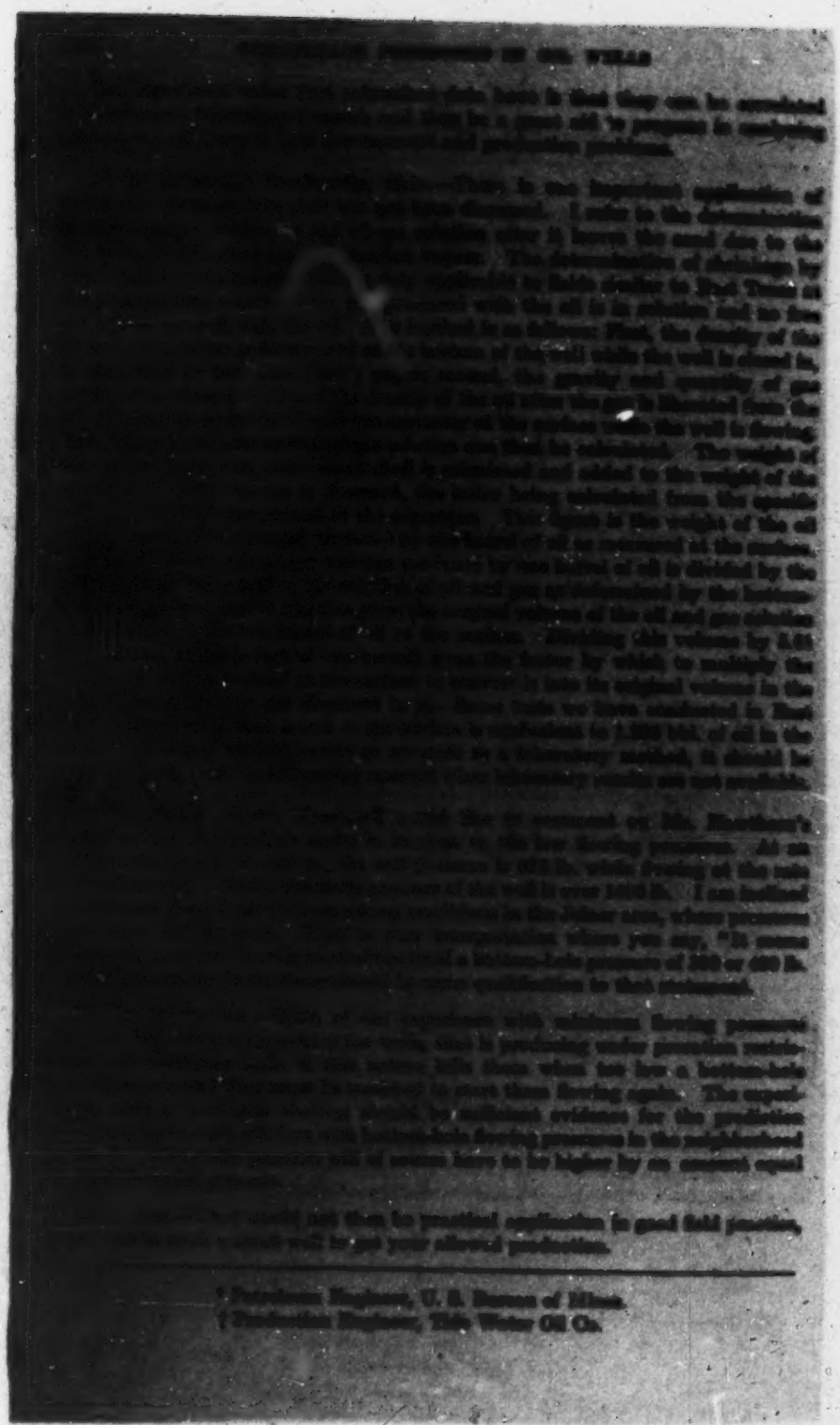


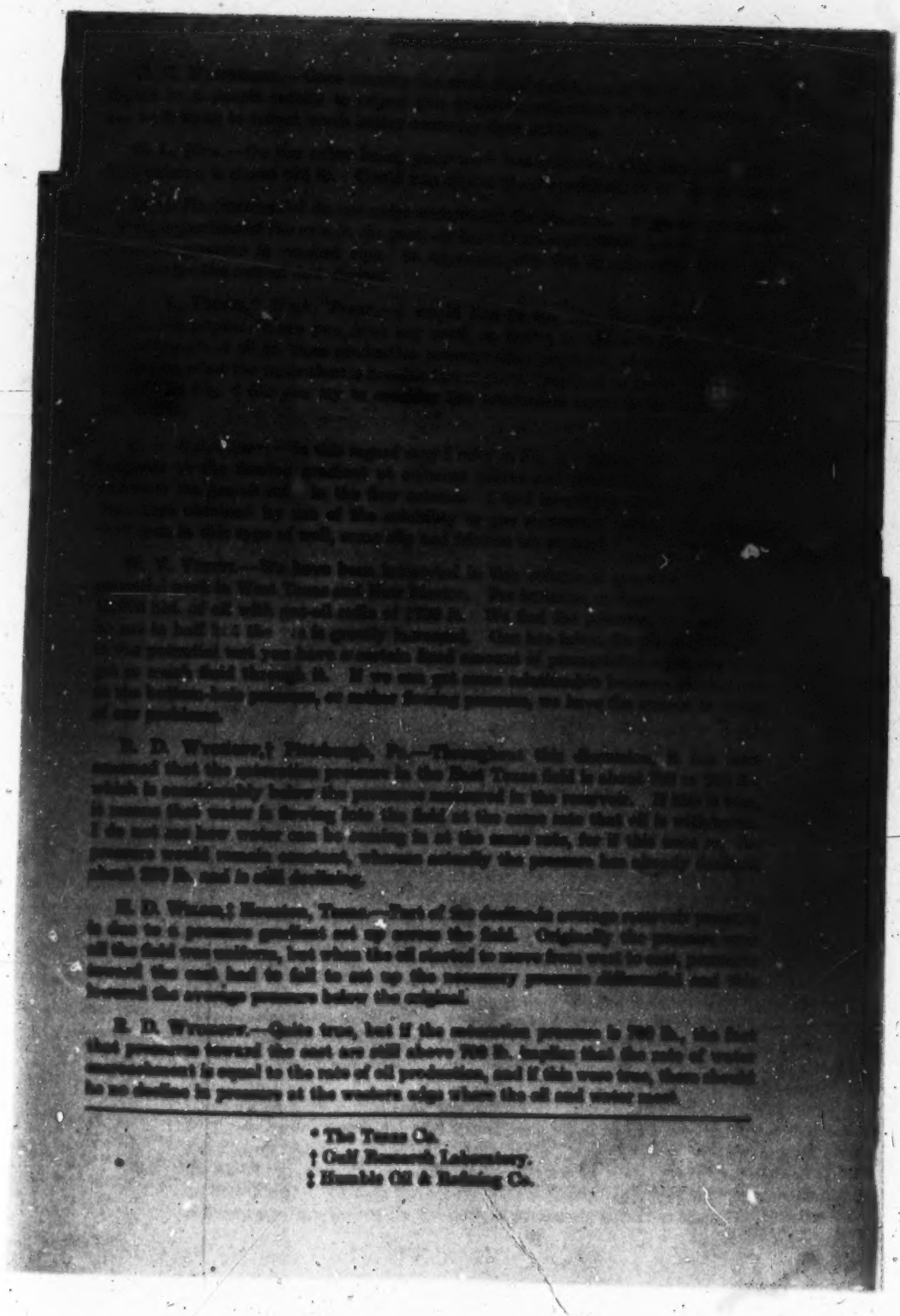
the final flowing pressure has been in the neighborhood of 700 to 800 lb. This figure appears rather high as from the above tests it would seem reasonable to expect flow to continue until the bottom-hole pressure has dropped to at least 300 to 400 lb. This should be of considerable interest to these companies operating in the field as it means an even greater flowing life than heretofore anticipated.

A series of experiments were conducted on a flexinole well for the purpose of studying the nature of oil and gas flow in various types and sizes of columns. The results are shown graphically in Fig. 5. Attention is called to the extremely low bottom-hole pressure of 14.8 lb. while producing through the 6⅝-in. casing. Curves 3 and 4 show the well flowing through 3-in. tubing set at different levels. The nature of the break in the curves at the bottom of the tubing is significant. With the tubing [illegible] 3110 ft., the gradient shows an oil-gas mixture coming up the [illegible] approaching the bottom of the tubing, while with the [illegible] 3135 ft., the break in the curve is sharp, thus indicating a [illegible] gas enters the tubing and lifts oil off the top of a more or less [illegible] Curve 5 is a flow column gradient for a tapered string of [illegible] to the replacement of 971 ft. of 3-in. tubing with 4-in., the [illegible] bottom of the tubing was decreased approximately 14 to [illegible] The relationship between the production-pressure drop [illegible] gas-oil ratio curve (Fig. 5) indicates the existence of a critical [illegible] apparently such points coincide closely at the same [illegible] of production. This should not be taken as conclusive at [illegible] to the nature and correlation of these curves are limited.

In Fig. 6 are shown the results of a recent subsurface test made on a high-pressure, high gas-oil ratio well in the new Burston area of [illegible] County, Kansas. Inasmuch as no back-pressure control test was [illegible] on the well only two points were available for drawing the [illegible] pressure drop curve. This curve is probably not a straight line but [illegible] likely takes a trend somewhat similar to that shown by curve 5, Fig. [illegible] peculiar condition is observed by noting the difference in [illegible] the static gradient and the flowing gradient. The static gradient [illegible] to be steeper with a greater pressure drop in the column than the [illegible] gradient. With the exception of the East Texas type wells, it is [illegible] this condition will occur only in wells having high gas-oil ratios and [illegible] reservoir pressures. The flowing gradient also shows that while the [illegible] producing at the rate of 12,000,000 cu. ft. of gas and 180 bbl. of fluid [illegible] day, a pocket of fluid exists at the bottom of the hole. This [illegible] indicates the stratification of oil and gas in the formation. At a depth [illegible] 3327 ft. the well tested 6,000,000 cu. ft. of gas and no fluid. After [illegible] ing the well to a total depth of 3390 ft. and allowing it to produce for a few days, it tested 12,000,000 cu. ft. of gas and 180 bbl. of fluid. It was at first thought that more gas as well as the fluid had been [illegible]







R. D. Wyckoff,† Pittsburgh, Pa.—Throughout this discussion, it has been assumed that the production pressure in the East Texas field is about 700 lb., which is considerably below the pressure maintained in the reservoir. It seems that water is flowing into the field at the same rate that oil is withdrawn. If the rate and later water can be passing in at the same rate, for if this were not true, pressure would naturally continue, whereas actually the pressure has already fallen about 200 lb. and is still declining.

R. D. Wyckoff, Houston, Texas.—Part of the decline in average pressure is due to a pressure gradient set up across the field. Originally the pressure in all the field was uniform, but when the oil started to move from west to east, pressure toward the east had to fall to set up the necessary pressure differential and thus lowered the average pressure below the original.

R. D. Wyckoff.—Quite true, but if the saturation pressure is 700 lb., the fact that pressures toward the east are still above 700 lb. implies that the rate of water encroachment is equal to the rate of oil production, and if this were true, there should be no decline in pressure at the western edge where the oil and water meet.

---

* The Texas Co.
† Gulf Research Laboratory.
‡ Humble Oil & Refining Co.

E. D. WILLIS.—I disagree with this argument, for I believe the water can keep up with the oil as it is withdrawn and still be accompanied by a declining pressure at the water-oil boundary. There must be a pressure differential set up in the Woodbine sand lying west of the field to cause the water to flow into the field itself. If water were absolutely incompressible, the pressure at the boundary would fall almost immediately to the new low value and then remain constant. However, because water is compressible, the pressure is only falling gradually instead of immediately to the new value and hence the decline in pressure now being observed. The compressibility of the water is small, of course, but there are such tremendous quantities present in the Woodbine section to the west of the field that the effect on retarding the decline in pressure is very substantial. Computations of the rate at which the pressure at the water-oil contact should decline have been made and they agree reasonably well with the observed decline. This fact, together with the evidence as to the low saturation pressure, convinces me that the water encroachment is keeping pace with the oil removal.

MISSNER.—All of my work along this line has been in East Texas. What I say is particularly the case there and possibly true in other fields. It is very possible that differences in flowing permeability factors of different producing sand beds may be detected and determined by use of the bottom-hole bomb. When neighboring wells producing from the same formation, but with different degrees of penetration, have a different permeability factor per foot of penetration, it is apparent that the permeability of the section is not uniform. I have in mind one case where two offset wells were tested; one had a penetration of 20 ft. into the pay sand, the other 9 ft. The permeability factor per foot of penetration of the well with 20 ft. of sand was considerably higher than the one with only 9 ft. This indicates, I believe, that the lower sands are the more permeable, and the better producers of oil.

When considering the permeability factor of sand it is important that we consider the difference between per foot of formation, and per foot of actual sand penetration. Mr. Hawthorn shows in curve 3 a method of correlating the various sections of the field by a permeability factor. I also tried a similar method but used actual sand penetration instead of total formation penetration. The results obtained in this manner agree a little more closely than those where total penetration is used.

It is probable that the pressure at which gas starts coming out of solution is largely dependent upon the degree of agitation. We have conducted tests of a somewhat different nature than Mr. Hawthorn's but with a similar aim. In our test we obtained pressures at which the gas came out of and went back into solution. The values we obtained were slightly higher than Mr. Hawthorn's, but may be accounted for by greater agitation. I believe the time factor and rate of flow must be considered as well as the agitation.

Mr. Nye brought up the subject of whether or not wells will flow at the solution pressure. I think that the wells will flow at what is commonly considered the solution pressure (700 to 800 lb. gage). We must bear in mind the difference between flowing pressures and shut-in pressures. You cannot talk of flowing pressures in respect to shut-in pressures, but rather of flowing pressures at some definite rate of flow. It is possible that these wells can be flowed intermittently down to these low pressures without swabbing. I know of one well in an area where there is no free gas that has a flowing pressure of less than 600 pounds.

In the main, I consider Mr. Hawthorn's paper to be a very good presentation of the subject, but there is one point with which I cannot agree. He writes as if it were impossible to determine rates of pressure decline for wells or for a field in general, such as East Texas. To date there have been sufficient records of well pressures taken to determine rather accurately the rate of pressure decline for the field. This is espe-

cially so where a definite daily withdrawal is being taken from the field. At the present time it is generally considered that the pressure decline is close to one pound per million barrels of oil produced. This pressure decline should continue until the solution pressure of the gas is reached, or until the effect of the water drive is materially increased. This pressure decline rate must, of course, be determined experimentally from field observations.

The pressure bomb allows us to bring the laboratory to the well and thereby obtain far better results than would otherwise be possible. Whereas it was previously only possible to use the irregular and unreliable surface pressures, it is now possible by use of a bottom-hole bomb to obtain precision measurements.

D. G. HAWTHORN.—I see no reason because in the past the pressure has declined at the rate of one pound per million barrels of oil extracted, for expecting or predicting that this relationship will continue to hold true even though the rate of withdrawal is held constant. The time necessary to set up or establish a producing differential or gradient in the reservoir is a vital factor and must be considered.

No. 1605 PH
Issued to ...
MARKED ... 19...
By ...
Deputy Clerk

Journal of the Royal Society of Arts.

No. 3408. [illegible]

FRIDAY, JANUARY [illegible]

NOTICES.

RECEIVED 20 MAR 23

NEXT WEEK.

WEDNESDAY, JANUARY [illegible], at 4.30 p.m. (Short Juvenile Lecture.) "Science in Daily Life," by Professor H. E. Armstrong, F.R.S., F.I.C. The Secretary for Colonies, Lieut.-Colonel [illegible], M.P., will preside. (Lecture III.)

The lecture will be illustrated with experiments.

Further particulars of this lecture's meetings will be found at the end of this number.

SESSIONAL COVERS FOR PRESENTATION VOLUMES.

For the convenience of Fellows wishing to bind their present volumes of the Journal, cloth covers can be supplied, post free, for 2s. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

FOURTH ORDINARY MEETING.

WEDNESDAY, NOVEMBER 29TH, 1922.

ADDRESS OF THE RIGHT HON. HENRY B. JACKSON, C.C.B., K.C.V.O., C.B., F.R.S., in the chair.

THE CHAIRMAN, in introducing the lecturer said he was the inventor of a very delicate electrical instrument which he had developed early in the war for the purpose of locating enemy gun positions. He would describe how, by careful research he had been able to apply the instrument to questions of practical purposes, making it a very accurate instrument for scientific acoustical measurements.

The paper was then read:

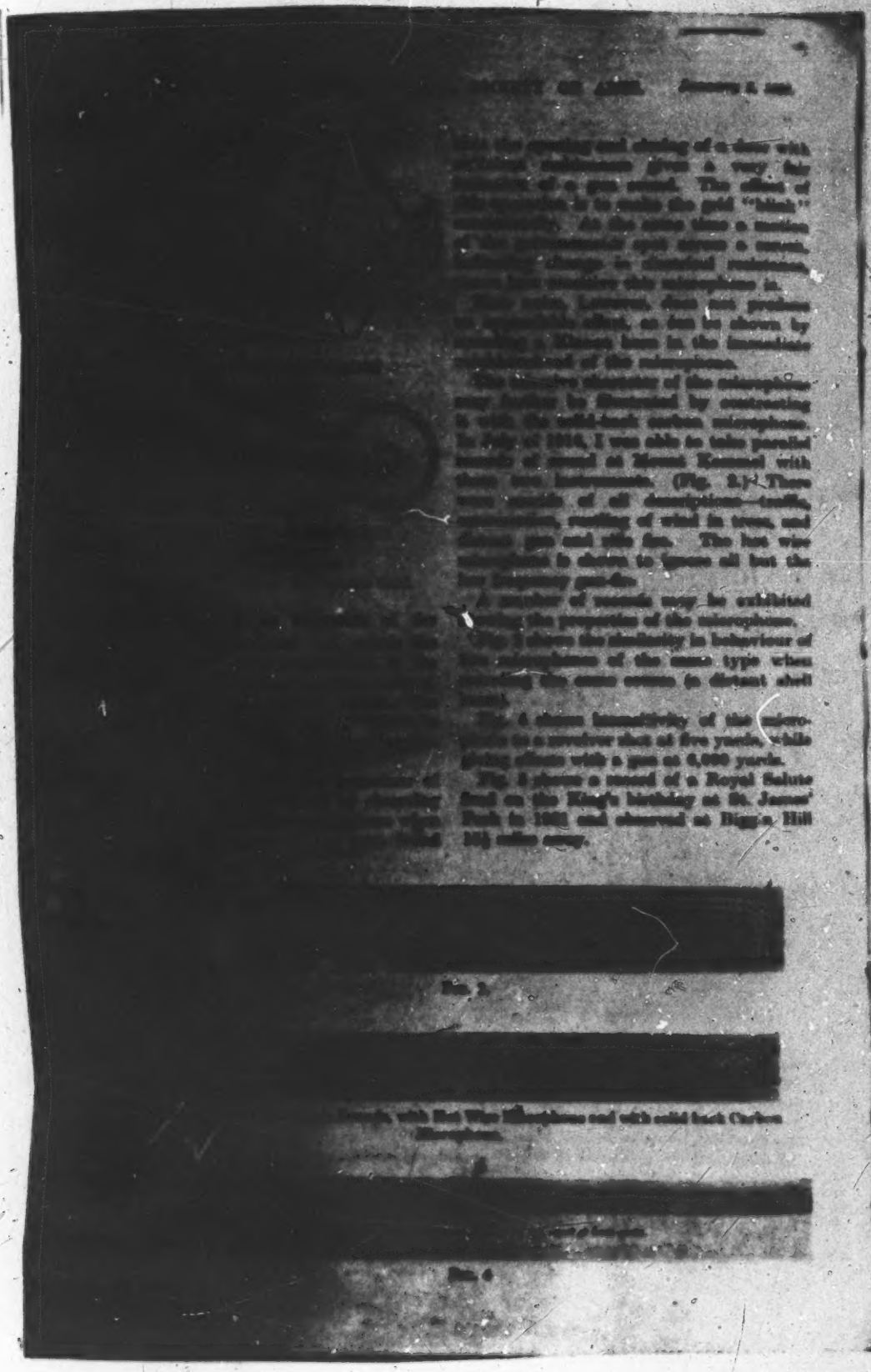
THE HOT WIRE MICROPHONE AND ITS APPLICATIONS TO PROBLEMS OF SOUND.

By [illegible] W. S. Tucker, B.E., D.Sc., A.M.I.E.E.

The subject of Acoustics or Sound has recently been brought into prominence by the application of the principles of wireless telegraphy to the location of a small enemy aeroplane, engaged in raiding London and the Department of Scientific and Industrial Research, and in the course of the work of this organization new lines and developments of general interest have been discovered. Some of these results have been described in this paper, and as they [illegible] the use of the Hot Wire Microphone, [illegible] has been made the basis of this paper.

[illegible] the first conception was suggested by Professor Wilson Hobbs, of Yale University, U.S.A., who showed that the microphone was not only the detection, but also the measurement of sound and vibratory motion.

In 1917 [illegible] designed to locate enemy guns and enabled accurately of a hostile gun or division. In one unit of which a small opening is made. When the explosive wave arrives at this opening [illegible] causing a small sound [illegible] that of air is projected into the [illegible]. In the path of this blast a very fine platinum wire grid is mounted, and by means of an electric current the grid is heated to [illegible] incandescence. (Fig. 1.) The effect of the blast is then to cool the wire, hence its electrical resistance and an effect [illegible] such as galvanometer of suitable type that a clear indication of the blast is demonstrated. The blast produced [illegible] [illegible] the current variations, and these again are dependent on the nature of the source of the disturbance. Hence the



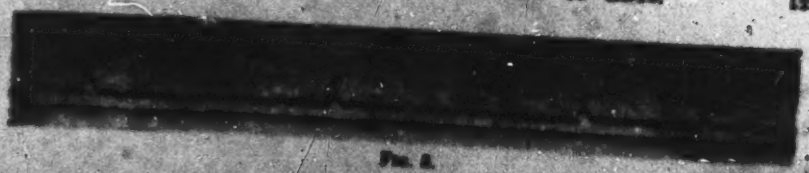


FIG. 6.

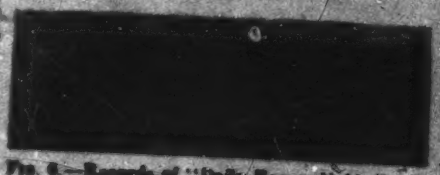


FIG. 6.—Records of "Daily Express" Air Bombs exploded over Hampstead Heath, as heard at Biggin Hill, July 14th, 1921.

Fig. 6 shows a record of nine bombs exploded on Hampstead Heath and observed at the same place, giving a range of 20 miles.

Distinctive records can be obtained from distant claps of thunder, and by means of three microphones sufficiently far apart it is easy to locate the origin of the lightning flash.

All these records have special characteristics by means of which either can be identified. It must be pointed out, however, that the sensitivity of the microphone depends, not only on the initial temperature and the dimensions of the hot wire, but also on the size of the microphone chamber. For the best reproduction of impulsive sounds, it is of advantage to use a chamber of about a cubic foot capacity and to make small holes or cracks in its walls to eliminate internal resonance.

From the above records it is seen that the microphone has an obvious application to such experiments as that recently conducted in Holland. The Meteorological Department of the Air Ministry asked me to try to obtain records of the great explosion of October 28th, and special arrangements were made for this purpose. Attempts were made to record the effect at Woolwich and Biggin Hill. The results of the observation at Woolwich are shown in Fig. 7, in which three well-marked effects are indicated. The times of arrival of the sound were respectively 19 mins. 39 secs., 19 mins. 45.5 secs., and 22 mins. 42 secs.

The records show, as would be expected, that the sound can arrive by a number of routes so far separated as to give separate impressions. The last effect which is the most prominent was very much delayed, and apparently consists of a higher pitched sound. The results obtained require careful study in conjunction with the known meteorological conditions, but the detail of this work cannot, of course, be described here. It is sufficient to say that from the known values of upper wind, the calculated

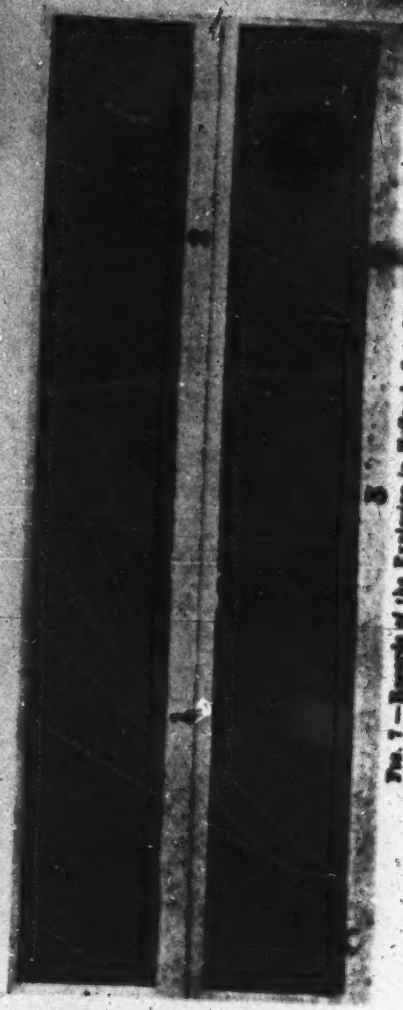


FIG. 7.—Records of the Explosion in Holland, Oct. 28, 1921.

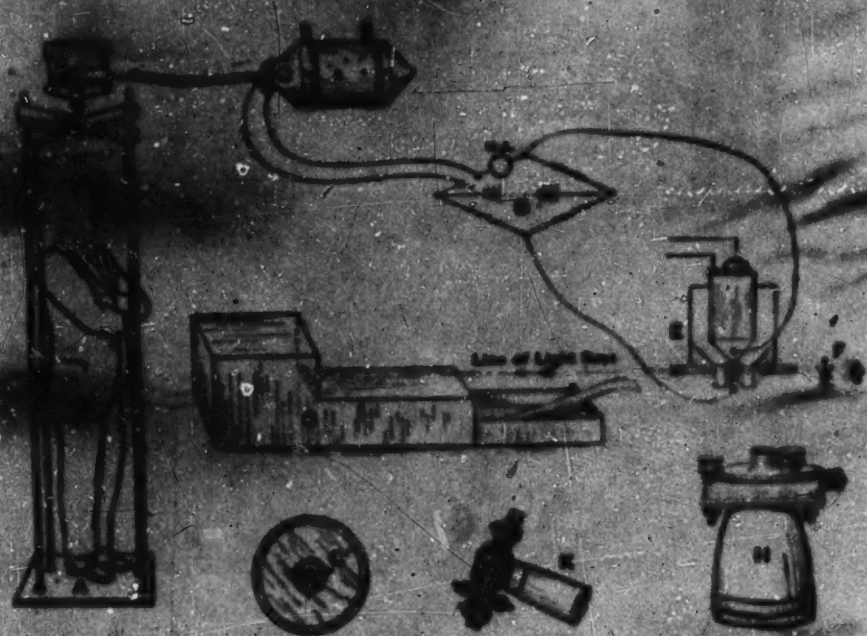


Fig. 8.

time to travel over the range (101.8 miles) is approximately that of the first values quoted.

The records of Bigelow Hill are very interesting and appear to give strong evidence of transmission through the ground. It is too early yet to report finally on our conclusions.

Probably the one thing that impresses one most in the above instrument is its surprising sensitivity to low frequency disturbances—disturbances which produce no effect on the human ear, since they are below our range of audition. It is immediately obvious that such an instrument might be harnessed to apparatus for the measurement of vibrations in structures. One such device has been described by Colonel Heald and myself[1] in a recent paper on "Recoil Curves as shown by the Hot Wire Microphone." Vibrations, some vigorous, some imperceptible, are communicated to the human body as the result of the forcible projection of the blood through the arteries due to the pumping action of the heart. Here the shakings of the body are transmitted to a diaphragm whose resultant motion pumps the air from a closed vessel to a microphone by a piece of rubber tubing, and the vibrating air cools the grid in such a manner as to indicate the nature of the body movements (Fig. 8). Associated with the peaks of the recoil records so obtained, we are able (i.) to identify certain movements in the blood, (ii.) to note how these vary with individuals in an apparently healthy state (Fig. 9), (iii.) to show that the peaks are higher during inspiration than expiration, thus indicating a breathing cycle, (iv.) to indicate how they vary when the body is treated with certain drugs, (v.) to observe how they enlarge after exercise (Fig. 10) and (vi.) to show how they may suggest conditions of disease or of mental agitation (Fig. 11). In more recent apparatus the subject, whose recoil is being tested, is placed on a couch, so that he is in a more favourable condition for giving records free from those of the involuntary movements of the body.

This discovery opens up a field of research purely medical or pathological, and to be quite certain of a proper correlation of physiological and physical processes, it is necessary to understand thoroughly the meaning of the physical changes in the hot wire when subject to blasts of air, whether continuous, impulsive or alternating in character. One effect, however, must

[1] Proc. of Royal Society, B, Vol. 92, 1922.

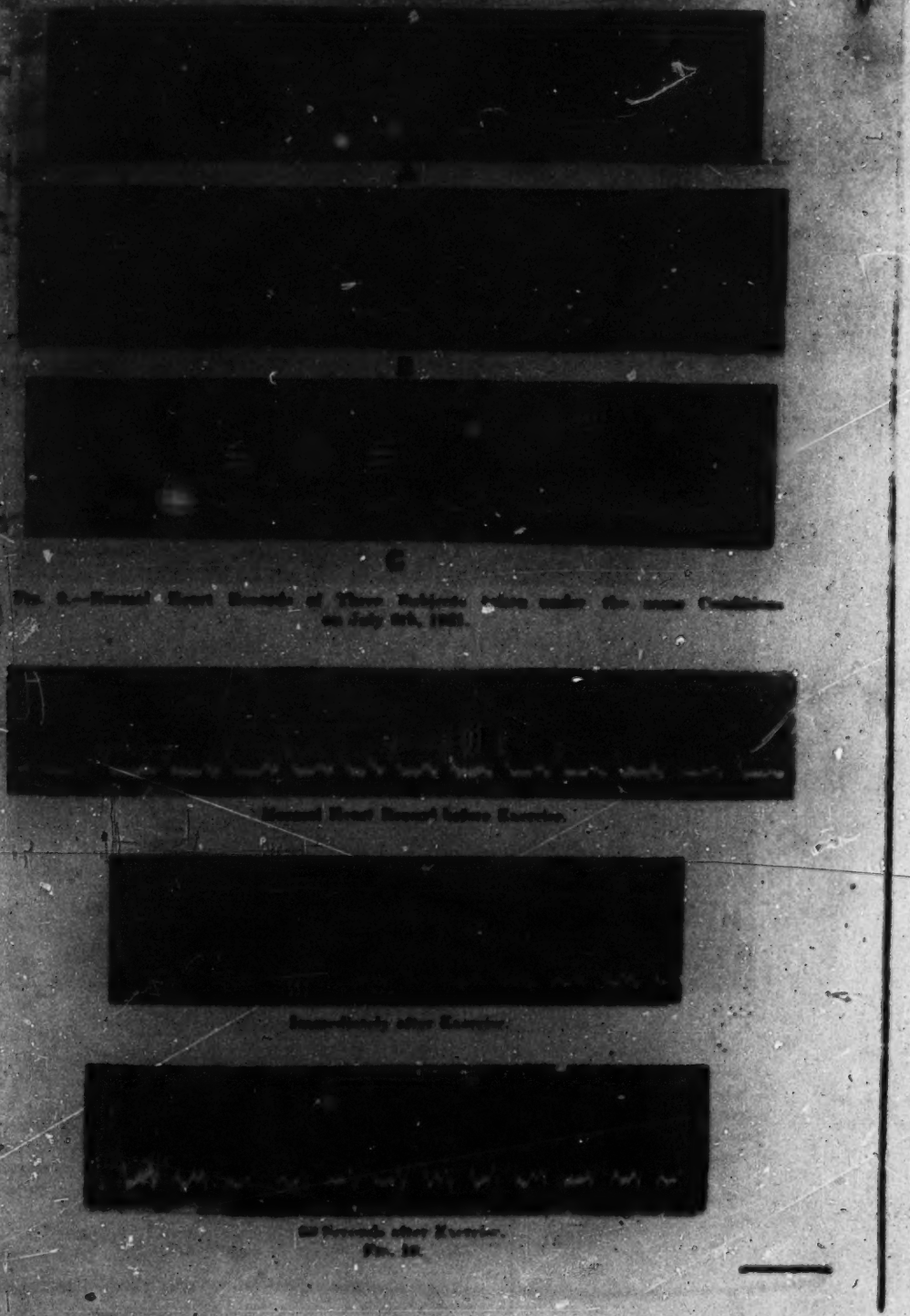


FIG. 11.—Showing Aortic Regurgitation.

be particularly referred to, viz., that the microphone wire is indifferent to the direction of the disturbing blast, since in both cases the wire is cooled, the resistance is diminished, and the record shows a succession of peaks entirely on one side of the zero line.

This statement must, however, be qualified by defining the position of the microphone grid. If the grid is vertical so that the hot convection currents from the wire are perpendicular to the motion of the particles of the vibrating air, the resistance change has twice the periodicity of these vibrations; but if the grid is horizontal, the resistance change tends to be in tune with them (Fig. 12).

(a) Grid Vertical.

(b) Grid Horizontal.

FIG. 12.—Microphone Records of Air moving in S.E.E.

The microphone as a measurer of impulses, is more difficult to explain than when used for the measurement of continuous sound. It was at first thought that the hot wire microphone could not be used for this purpose, but the remarkable magnifying power produced by resonance exhibited by Helmholtz, and its theory has received a complete treatment by the late Lord Rayleigh.[1] From known dimensions of the resonator, its magnifying power can be calculated, and it can be shown that

[1] Rayleigh's Theory of Sound. Vol. 2. Chap. XVI.

us to get sufficient disturbance with sounds of one predominating frequency to affect the hot wire.

In the above statement it was shown that for accurate recording, resonance should be discouraged in the containing vessel by perforating its walls. If, however, these walls were left intact, it was found that the vessel with its microphone orifice had a very definite note of its own to which it would respond with great vigour. Excited by the sound of the same musical pitch, the resonator, as we may now call it, produces intense vibrations in the neighbourhood of the hot wire thus cooling it, and moreover, cooling it periodically. This resonator is no new discovery. It was

resonance in a given case is confined to a very short range of frequencies, comprising about six per cent. of the mean frequency, so that it is only capable of responding to a range of about one musical tone.

The overtones to which it can respond are of high pitch, and are relatively feeble, this making it the most selective type of resonator known.

An approximate treatment of the theory of the instrument is given in a recent paper before the Royal Society,[1] in which the

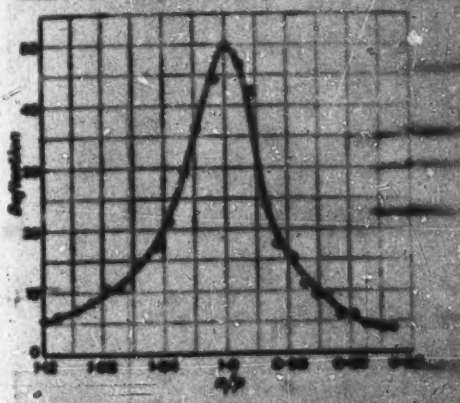


FIG. 13.

resonance curve of Fig. 13 is given. This has been obtained by subjecting the resonator to the sound of a siren whose pitch is gradually raised, and measuring the effect produced. This calibration of the instrument can also be demonstrated by a simple experiment.

It has already been stated that the resistance of the hot wire is not only diminished by the vibrations in the neighbourhood of the microphone, but this resistance is also subject to variations of a periodic character. If the variations of electric current resulting from such periodic changes be magnified by the valve amplifier, the resulting current is sufficiently large to affect a telephone. If, then, we have by the side in the neighbourhood of the microphone the response to a given note is maximal audible, and by means of a loud speaking telephone can be demonstrated to a large audience.

The microphone may be tuned by altering the volume of the resonator or by altering the dimensions of its neck—that is, larger volumes or a longer neck would be employed for a lower pitch. In general, alterations of volume is the most satisfactory way of tuning. For the sake of illustration, a microphone tuned to 512 vibrations per second, has one quarter the volume of one tuned to 256 vibrations per second, if all the rest are equal.

One of the advantages of this type of microphone is its insensitivity to other disturbing noises, as can be shown by substituting a galvanometer for the telephone, so that the response of the microphone is shown visually. Here the magnified alternating current is first made unidirectional by means of a crystal rectifier. A Klaxon horn and other disturbances were produced in turn, but the slightest kick on the appropriate note is easily detected.

Even keeping the microphone continuously in operation does not appreciably affect the speed clock makes. A very useful application of the instrument is for timing, and this is easily done by coupling it with observing the effect on a suitable galvanometer. For this purpose also, the hot wire microphone can be placed inside a room, and was shown by the galvanometer deflection the variation of intensity of sound at different points in the room.

Even in this form, the microphone has not shown its sensitiveness limit. It can be demonstrated that if the microphone be mounted with its axis perpendicular to the wall of a cabinet box, whose side consists of a sliding door, a small hollow sphere is obtained if the door be opened to a certain degree. The box itself becomes a resonator, and when used with the microphone enables the combination to be readily tuned to a sound of the correct pitch.

This phenomenon of double resonance, in which the sound waves come through the slits between the two boxes but in unison with the sound outside, should be of service in many scientific researches. The combination outside and can, but even moderately quiet and give a wide choice range of tuning, while at the same time giving high magnification.

A resonator of this type is shown in Fig. 14, and the hot wire is produced by a coil of nickel wire that was connected across the usual amplifier and detector. Fig. 15 is the side resonator, in the usual manner

[1] Rayleigh and Sutherland, Proc. Roy. Soc., A, vol. 98, p. 265.

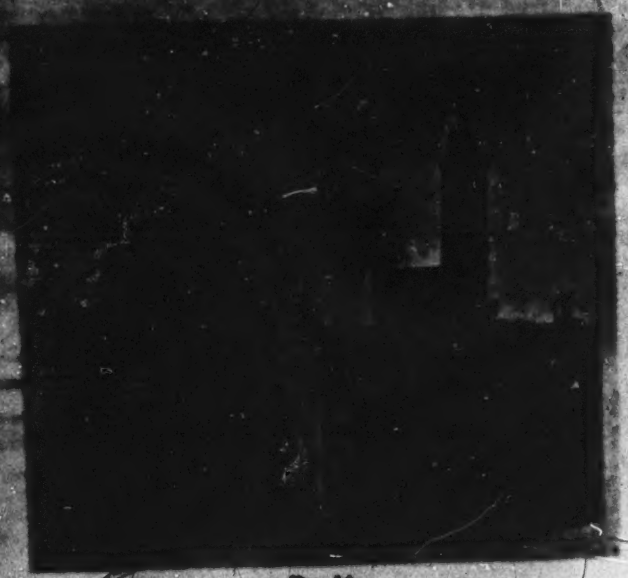


FIG. 14.

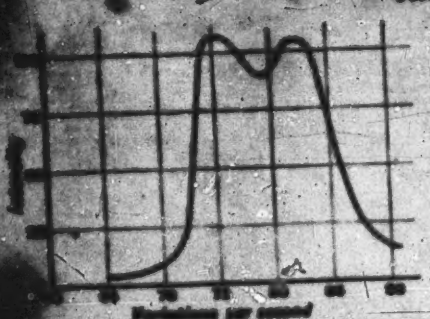


FIG. 15.

distance of sounds we have been able to produce and especially pick up inaudible sounds within the range. Its high selectivity also enables it to hear in the midst of disturbing sounds.

The greatest trouble that all microphones experience is disturbance due to wind. The hot wire microphone is specially susceptible, and much attention has been given to the solution of this difficulty. We are, however, greatly indebted to Mr. H. S. Player for the discovery of a very efficient wind screening device. This consists of the ordinary "loofah," the effect of whose fibrous structure is to break up any wind impulses without obstructing the passage of air or of sound. The microphone of Fig. 14 is protected with such a loofah screen which is here shown detached from the box front.

We may now turn to some investigations in which the microphone has been satisfactorily applied. Its consistency of behaviour enables it to be employed for the accurate comparison of sounds of the same quality, for it has been shown in the paper last referred to, that the ohmic change produced in the hot wire of the microphone is a direct measure of the intensity of the sound.

If the sounds to be compared are relatively feeble, a well tuned microphone would be employed, but if the sound is very intense, as in the neighbourhood of the Trinity House sirens, a microphone whose note is well below that of the siren is adopted. Thus, two fog horns were compared on the Channel Islands with a microphone of pitch 80 vibrations per second, that of the horns being 180 vibrations per second in each case.

If we use a source of sound of a given pitch, we can find out

(1) How the transmission of such sound is affected by weather conditions.

(2) How the sound is distributed in certain enclosures, such as rooms of different sizes and shapes, and how that sound is modified by opening windows or doors or distribution of the audience, or the furniture in a room.

(3) How the sound is modified, magnified or distributed by the intervention in its path of trumpets, reflectors or obstacles.

Dealing with the first class of experiment, we obtain data of considerable importance to meteorologists. The study of meteorological acoustics was developed at our station at Kingsgate, near the North Foreland, and this station was [illegible] for working [illegible] different light vessels, whose [illegible] are indicated on the map (Fig. 16).

as heard at Kingsgate—seven miles away. The instrumental effects were checked by ear, but it was only by the instruments that such large variations could be appreciated.

Fig 18 shows a record of the [illegible] Light Vessel (three blasts of the [illegible] pitch) at a range of nine miles and [illegible] shows a record of the Kentish Knock Light

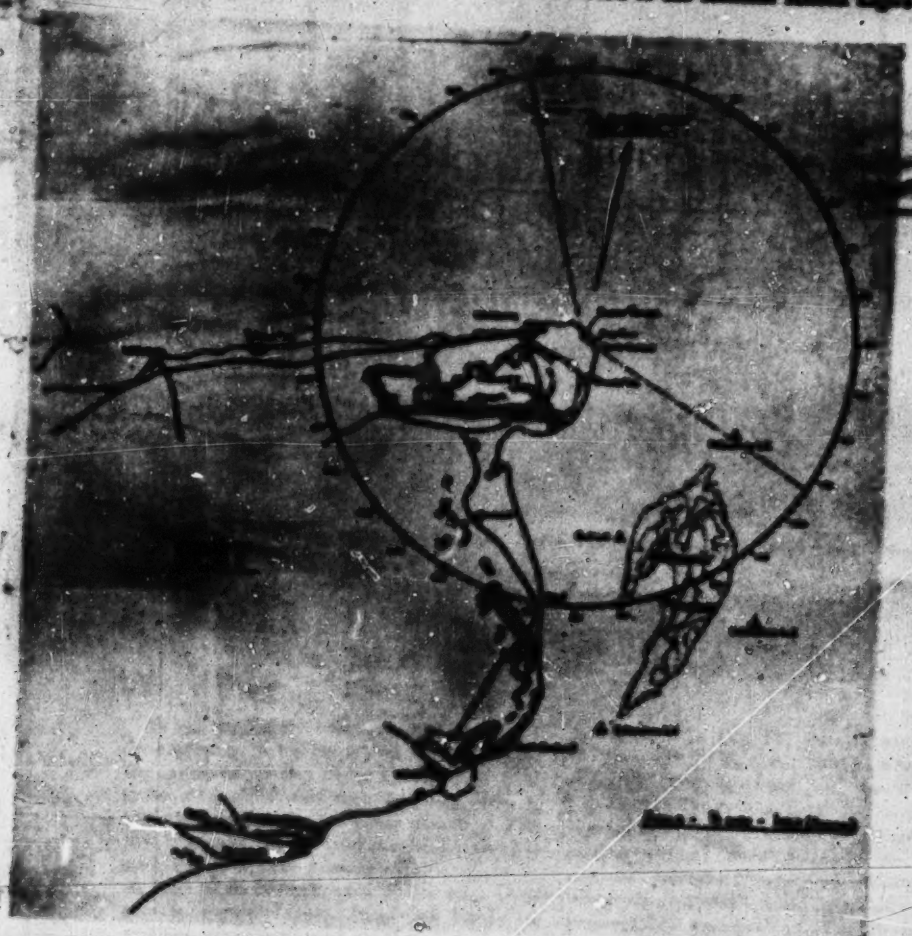


Fig. 16.

Fig. 17 shows how remarkably the intensity of the received sound varies on a typical English summer day when the sky may be clear or flecked with white cumulus cloud. The heights of successive peaks correspond to sounds emitted at minute intervals by the North Goodwin Light Vessel Siren

Vessel Siren—one blast—at a range of 10 miles, the sound taking 1½ minutes to arrive. This sound was quite inaudible, and here all sea and local noises were tuned out—thus illustrating the advantage of microphone reception over aural reception in this case.

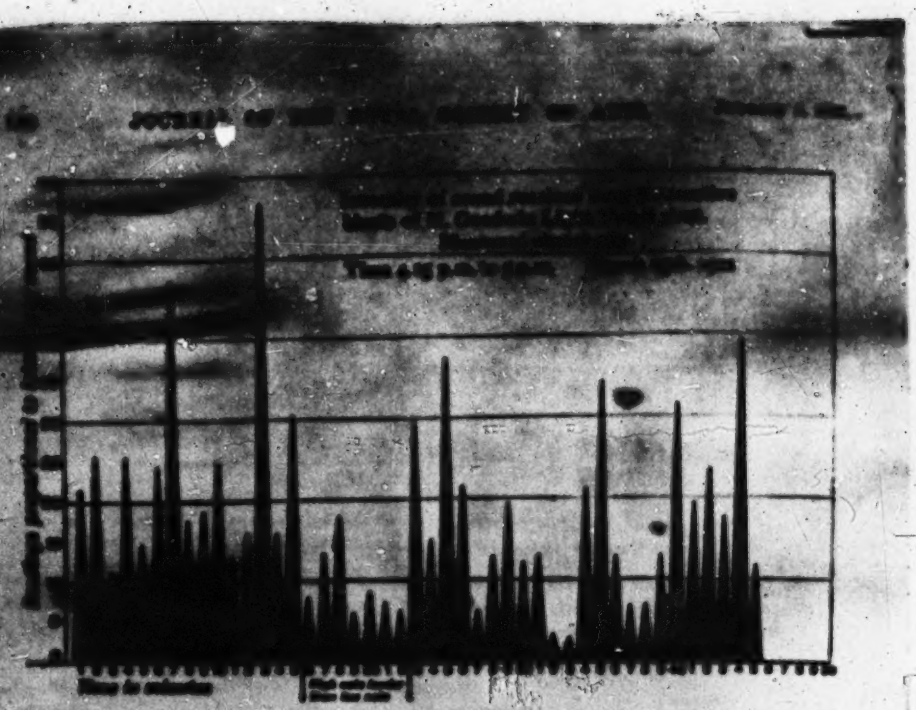


FIG. 17.

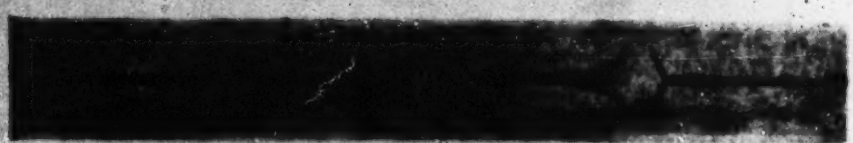


FIG. 18.—Record of the Tongue "Light Vessel Siren," 2 Blasts, Range 9 miles.

FIG. 19.

In all the above cases, doubly resonated microphones were employed, and through the courtesy of the Elder Brethren, a long series of observations were obtained, extending over a period of several months. For this work the North Goodwin Siren provided special blasts for periods of 15 minutes on four days in each week. We were thus able to record sound under all kinds of weather conditions and to obtain from the data thus supplied certain laws governing the conditions of audibility as affected by weather.

Toward the end of May of the present year the Elder Brethren afforded me the opportunity of working with the sirens on the Channel Islands, and I was able to take records on the Trinity yacht "Patricia," while cruising in the neighbourhood of the Casquet Rocks. With the microphone of Fig. 14, records were taken of the new Diaphone Horn which has recently been installed on the Casquets to replace the standard pattern siren. During the test, the effects of different conditions aboard were observed by taking records between the siren blasts. The vibration and ship's noises generally did not produce any serious effect. Fig. 20 shows the blast records as observed at a range of two miles. The abruptness of the increasing sound a valuable property of the diaphone is clearly demonstrated, and contrasted with the siren. No attempt was made to reduce the sensitivity of the microphone. At a distance of 4½ miles the sound was still too intense to obtain the whole of the record on the sensitised paper strip using full sensitivity. The time at our disposal prevented our working on

FIG. 20.—C. Diaphone and Siren Records Compared. Range 2 miles.

extreme ranges, but it is believed that a range of at least 20 miles could have been recorded by the microphone. The superiority

bearings gave no such indication, and the North Goodwin siren—slightly to the south—gave a sound perfectly free from echo.

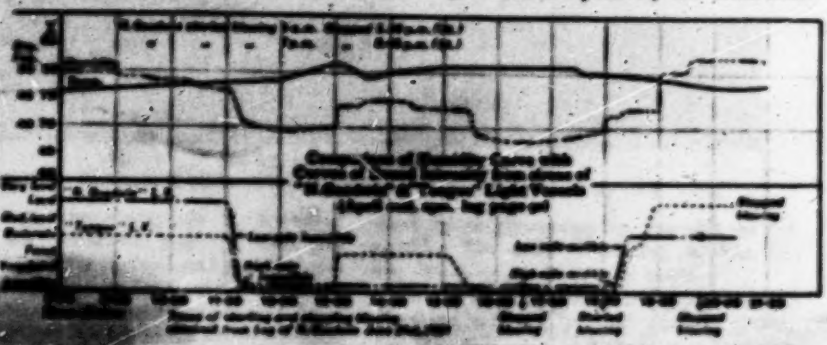
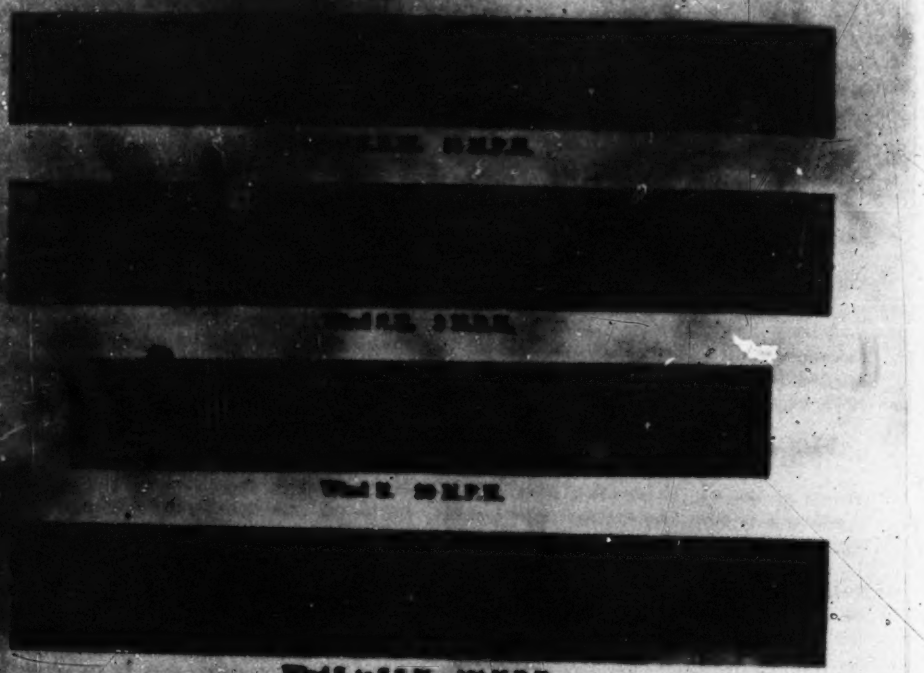


FIG. 21.

Fig. 21 shows the effect of a shifting fog on the audibility of the North Goodwin siren, and its intimate relation to changes of humidity. It is seen here that at points where the humidity undergoes sudden diminution there is corresponding diminution in the sound of the North Goodwin siren. Variation in humidity means variation in fog-density and during the interval of silence, shown in the diagram, there was a fog bank lying between the source and the ear, but never completely enveloping both. A uniform fog is even more satisfactory for sound transmission than average clear weather. It is the variation in fog density which is so fatal to good listening. This evidence is in keeping with the late Professor Tyndall's observations at the South Foreland.[4]

It is generally accepted that sound is

4. Tyndall's Sound. Lecture VII.



Wind E. 20 M.P.H.

Wind E. to S.S.W. 12½ M.P.H.

FIG. 21.—Variation of received Sound with Wind (Sound approaching from S.E.).

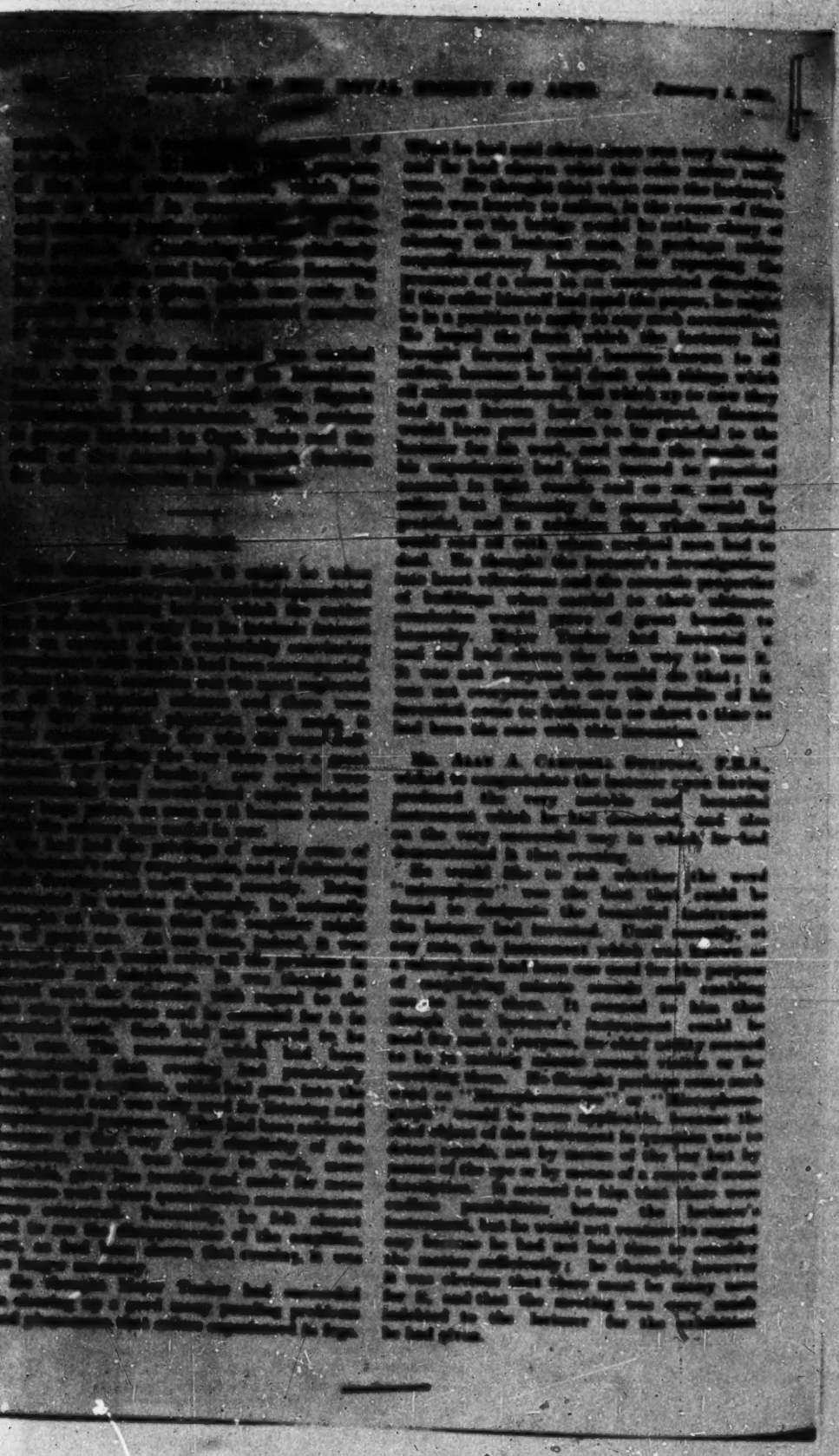
Sound travels favourably in a following wind. Fig. 21 shows, however, that this rule is frequently broken, and has directed our attention to a fuller study of upper wind and temperature conditions. If a following wind has a velocity which increases as we ascend it is favourable for sound. The same conditions obtains with an adverse wind which diminishes in strength as we ascend. The cases illustrated in Fig. 22 are examples of these two cases.

Fig. 22 is of interest as it shows a record of sound arriving by two distinct paths. The day was clear and there was a strong following wind, whose velocity alternately increased and decreased as the height we-

Wind E. 20 M.P.H.

FIG. 22.

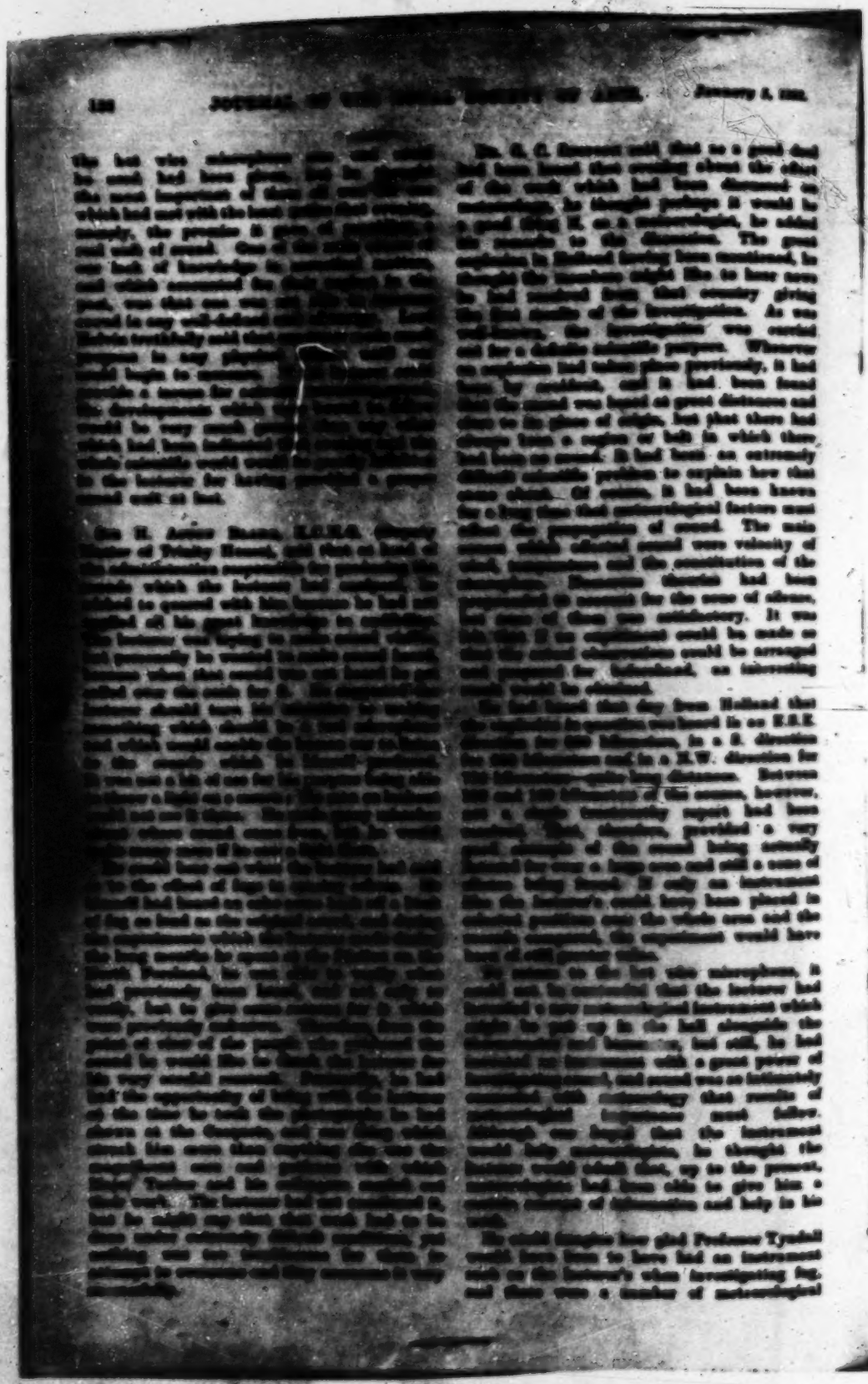
[illegible] the object is the source of [illegible] [illegible] [illegible]



Lieut.-Col. A. Cowan said that for the past three years he had been chiefly responsible for the Lectures, but he had not been responsible for the work. He thought everything apart that the Society's Secretaries had done remarkable one, and included in it everything the saying with regard to "heating events the phenomenon." There was one point in the paper on which he would like to enlarge. He thought the appointment of the Society's Lecturers to mechanical research would be of just the highest, as all events one of the most important of the developments. The examination of electric vibrations or variations in temperature and electrical apparatus would be found, he thought, of the greatest value and importance.

Colonel C. E. Heath, C.B.E., R.E., wished to associate himself with other speakers in thanking the Lecturer, with whom he had been in official relations on such during the past three years. It might be of interest to the Meeting to know the origin of the Lecture with which Major Tucker had started. In 1901, he was desirous to conduct the medical examinations of boys, and it was decided to weigh them accurately. When weighing them on a weighing machine, the only one obtainable at that time, it was noticed that the head moved. He had noticed that previously, but had simply noted. A year passed by and then a Committee, Colonel Heath being chairman, met to discuss the matter, and he found that in the year 1901, and probably the years then, Major Tucker, with Lieutenant Hall, had been carrying out experiments of the head with a few comparatively simple instruments, and with other instruments of the head part of scientific work of the kind in connection with recruiting, produced the results which had been described in the first portion of the paper, and all the physical part, which was in the Lecture.

They usually dealt with that was the use of making head records of the kind in question when one could have to deal with a recruiting. The records was that it provided a permanent record from which, from time to time, one could measure the growth of the body, and to see whether the physical development was taking place, and to see whether the various measures of care and training which were adopted were producing the results which were desired. In connection with the Lecture, the question of the physical efficiency of individuals, it should be possible for their records to be kept from time to time, and such records should be made and the opinion of the medical officer. Such records were extremely useful for the training officers, and he had received many such records of the chest of school on the return of the head. When the Medical Officers should not only show the records of any one individual, but also the records of a number of individuals, and the average of a number of individuals, and the average of a number of individuals, and the average



problems the lecturer had not mentioned that evening in which it might be useful, such as finding out the velocity of the air in the upper atmosphere, which was of great importance for many meteorological problems, and also for the application of meteorology to such things as gunfire.

Before sitting down he would like to draw attention to an aspect of the work which, to him, was very striking, namely, that it had been done entirely by Government, at Government expense in a Government Institution. It was practically pure science, and it was, he thought, an interesting sign of the times that Government had worked and was working along these scientific lines. Before the war very little was known of the matter, but now our had the three great fighting forces, the Army, the Navy, and the Air Force, joining together and employing men like the lecturer to investigate scientific problems. What was still more striking was the fact that an investigation which had started with the idea of fixing the position of guns so that not only the guns, but the men working them might be wiped out, had been adapted to things which were of use to the people at large and for the investigation of medical problems and as a help to investigators. It showed that one could not touch any scientific problem even for assistance in war without getting some great advantages for peace.

Dr. L. Imanuel wished to add a few words to emphasise the importance of the lecturer's work from the point of view of the Merchant Service. Personally, he was an official of the Chamber of Shipping of the United Kingdom, and he could testify that it was of the very greatest interest to those connected with merchant shipping to know that the invention which had been described, and which was originally designed for war purposes, was now proving useful to the Institute of Marine Engineers who were using it in order to differentiate between one type of steam and another. The publication of the various log sheets which gave warning to seamen was a matter of the very greatest importance to ship-owners, but, while in that regard it touched shipowners directly, it also affected them in another way indirectly, in so far as the Meteorological Office, who kept them informed of everything that was happening between the sun and the horizon in the various portions of the globe, were assisted by it. In addition to the kind words which the Chairman, representing the Admiralty, had spoken, he thought it was not out of place to add something as a representative of merchant shipping.

Mason Turner, in reply, said that with regard to the gales raised by Mr. A. Shapland Swinton on to the lecture platform, the question of making the instrument had caused a great deal of handwriting and discussion, and the word "atmometer" resulted simply from a difference of opinion among all the people concerned. It was really a measurer of blasts of air caused as a result of sound, but it was extremely difficult to think of a word which was sufficiently simple, without being pedantic, to describe how the instrument worked.

With regard to Sir Aston Blake's remarks, he would like to say that he and his colleagues had very much at heart the kind of work Sir Aston described—how to make sounds audible to the mariner, knowing that the ear was of more importance than any instrument which could be devised. The only way in which he could help in that matter, however, was by devoting his attention to the production of sources of sound, and he was glad to say that his researches had enabled him to follow out this line of work. The applications it had met in testing sounds were they had been produced; unfortunately, at the present time, sufficient progress had not been made to enable the atmosphere to be used with great effect, but that was a matter which was in the forefront of their programme and he hoped they would be able to supply the Elder Brethren with the information they required.

The Chairman said that a very interesting lecture had been followed by a very good discussion, which he hoped would be duly appreciated by those in authority. He asked the Meeting to accord a hearty vote of thanks to the lecturer for his interesting paper.

The vote of thanks was accorded unanimously and the meeting then terminated.

[redacted]

In the Journal of 1922 (Abstracts, page 97), is an article headed "Engineering Work Outside Industry."

This item was drawn to the attention of the Royal Society of Arts by H. G. Ramsay in 1921. Samples also of that item were submitted to the Key Industry Committee and to several persons, all of whom pronounced it equal to the best British line.

Mr. Brown, an Englishman, at the head of the Columbia Agricultural Department, had some pamphlets for the Columbia Government on this item, and promised it [illegible] of Fine Open.

The Islands have never properly developed it, and it is unlikely [illegible] under the names of Sensible Knitting, Sensible Jumper, Sensible Stockings and Fine Hose.

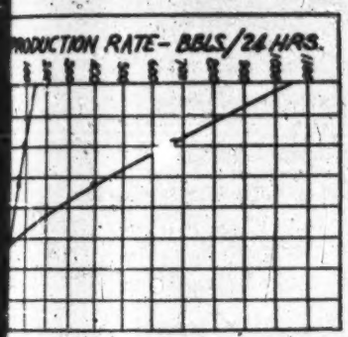
The name of Fine Columbia is [illegible] as it gives satisfaction in all of the Tropical and South American countries from the equator south to 35 degrees south of the equator. In other words one representative is in different [illegible] one representative is in different [illegible] in [illegible] the [illegible] of them; but by showing up the bale of the season, coming on right

ottom Hole Pressure Bomb Aids in Selection of Equipment for Wells

By HAROLD K. IHRIG

This article describes the use of recording type bottom hole pressure bombs in securing necessary information for selecting equipment in large pumping wells. The data gathered may also be plotted as curves and by the projection of these curves arrive at a close approximation of the total volume of fluid a well is capable of producing per day.

Considerable work has been done past several years on the use of bottom ressures as applied to flowing wells as a for equitably prorating restricted fields and ance in the selection of proper production and equipment. It is only recently, how- hat the use of bottom hole pressure bombs me into a very widespread use as a means rmining fluid level conditions and the vol- f fluid a pumping well is capable of pro-



—Representative test curves in which il rates of oil and water production are d against the respective bottom hole pressures

, and thereby furnishing a basis of great nce to engineers in making suitable selec- of producing equipment that will, as nearly ible, produce the well to capacity.

those pumping wells making large volumes er the operator is sometimes at a loss to ine what extent he is pumping the well and is naturally undecided as to what type ping equipment to use because of the large ditures entailed in making any major ge.

a means of arriving at a close approxima- of the capacity of a pumping well with a fluid level the recording type bottom hole e bomb has been of great help and is re- g an increasing amount of use. There are l types of these recording bottom hole bombs e market at the present time and while there wide difference in the working principle, bility, ruggedness and cost the results ob- are comparable and, in nearly all cases, le.

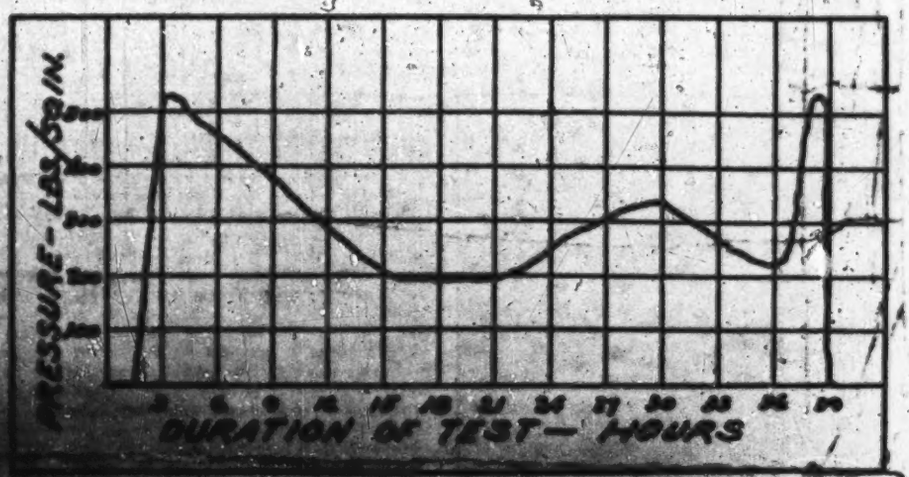
et a typical case in which the use of a h hole pressure bomb of the recording type d to be of great value to an operator who ronfronted with the problem presented by a pumping a large volume of water and a com- ly small volume of oil, due to the equip- with which the well was being produced. ution was to select other pumping equip- that would move a large volume of fluid thereby increase the oil recovery from the . The handicap of not knowing the approxi- total volume of fluid the well would pro- nor the probable volume of oil the well d produce, in case the well was pumped, made his selection of new equipment, other t might be, a bill of sale proposition. In e consideration of the use of a bottom hole pressure bomb in the use of a bottom hole pressure bomb ainder without serious question the total ity of the well.

pressure element used in this type of bot- bomb is located in the bottom part

steel stylus is attached to the free end of this tube in such a manner that any variation in pressure will cause this stylus to move in a vertical plane. This steel stylus, to record the variations in pressure in the tube, moves over a card of highly sensitized paper which records the path made by the stylus. This card is of such size that it is formed into a cylinder within the bomb and is rotated by the small timing mechanism in the bomb. Each pressure tube must be calibrated against a deadweight tester to determine the length of travel made by the stylus per 100 pounds per square inch pressure. As the recording medium, or card, revolves once in 24 hours, and the timing mechanism usually runs for a period of from 36 to 42 hours the ultimate curve recorded is one in which the last 12 to 15 hours overlaps the part of the curve drawn in the first 12 or 15 hours of the test. Figure 1 is an approximate reproduction of a recorded test with the overlapping part of the curve transposed to form one continuous line.

The bomb was inserted in the gas anchor immediately below the pump being adequately cushioned by both steel springs and rubber to keep it as free from vibration as possible. The tubing was then run into the hole, the rods run and the well put to pumping. The well was pumped at maximum rate for approximately 21 hours then slowed down for a period of 9 hours when it was again run at the speed used at the start of the test. The curve drawn by the bomb, shown in Figure 1, will reveal the entire operation. The rapid rise of the curve is due to the increase in pressure created by the submergence of the bomb as it was lowered into the fluid, and reveals a bottom hole pressure of 825 pounds per square inch. The rapid drop in the bottom-hole pressure, caused by the pumping of the well, to a pressure of 190 pounds indicates that the equipment used to produce the well was operating at its maximum capacity and had lowered the fluid as far as it could. Production at this point was at the rate of 95 bbls. of oil per day and 670 bbls. of water per day. The operating equipment was then slowed down and the fluid level allowed to rise. With the well being pumped at about two-thirds the usual speed we find that the fluid came up the hole sufficiently high to create a pressure of 325 pounds per square inch on the bottom of the hole. Production at this point was at the rate of 53 bbls. of oil per day and 390 bbls. of water per day. By plotting the several pressures against their respective production rates we are able to arrive at two curves which when projected will give a close approximation of the true productivity of the well. Figure 2 shows these figures plotted and the curves extended. It will be noted that at 825 pounds bottom hole pressure the production rate is zero, at 190 pounds bottom hole pressure the rates of 95 bbls. of oil and 670 bbls. of water per day, and at 325 pounds bottom hole pressure the rates of 53 bbls. of oil and 390 bbls. of water per day. By extending a line from the zero production point through the two oil production rates and to the zero pressure line, and doing the same with the water production, we find that the well is capable of producing 145 bbls. of oil per day with 1,050 bbls. of water per day.

With the knowledge that the well in question is capable of producing 1,195 bbls. total fluid, the operator of the well has some definite information upon which to base his decision in the selection of new equipment to produce the well.



Typical graphical recording of bottom hole pressures in a pumping well. The cross section- ...ure was produced on the card after it was taken from the well, and correlated with the time ...of test and the pressures recorded by use of the calibration curve for the bomb

DEFENDANT'S EXHIBIT K-8

BOTTOM-HOLE PRESSURES IN OIL WELLS*

By C. V. Millikan,† Tulsa, Okla. and Carroll V. Sidwell,‡ Seminole, Okla.

(Tulsa Meeting, October, 1930)

There is nothing more important in petroleum engineering than a definite knowledge of the pressure at the bottom of an oil well at any existing operating condition, and the relation of this pressure to the pressure within the producing formation. A knowledge of bottom-hole pressures is fundamental in determining the most efficient methods of recovery and the most efficient lifting procedure, yet there is less information about these pressures than about any other part of the general problem of producing oil.

Determination of Bottom-Hole Pressures

Bottom-hole pressure may be calculated or determined by several methods. On an inactive well it may be calculated from the fluid head or, if the well is shut in, by adding the casinghead pressure, the static head of the gas and the fluid head. In wells flowing naturally through tubing the pressure at the bottom of the tubing may be calculated by adding the pressure at the casinghead be-

---

* Published by permission of the Amerada Petroleum Corporation.

† Chief Production Engineer, Amerada Petroleum Corporation.

‡ Production Engineer, Amerada Petroleum Corporation.

tween the tubing and the casing and the pressure due to the weight of the column of gas, but there is always possibility of error caused by fluid being in the annular space above the bottom of the tubing. If a well with tubing is flowing through either the annular space or the tubing, sufficient gas may be injected through the static space to insure that it is free of fluid but not sufficient to establish an appreciable friction loss. The pressure at the bottom of the tubing can then be calculated by adding to the pressure at the tubing head the pressure due to the weight of the column of gas. This is probably the most accurate method of calculating bottom-hole pressures. In wells flowing by gas-lift, the pressure at the point the gas enters the flow may be calculated by a gas-flow formula. Several types of pressure bombs have been used to measure the pressure at the bottom of wells. One is a piece of steel tubing with a check valve in the bottom and a connection for a pressure gage at the top. It is lowered into the well to the point at which the pressure is

No. 1665-PH
Def. Exhibit No. K-9
Marked 11/4 19 22
Deputy Clerk

Density of Oil-gas Columns from Well Data

By William Victor Vietti,* Wink, Texas

(Tulsa Meeting, October, 1930)

Actual field data from several wells are used to illustrate the application of the method of determining the average density of the fluid column in a flowing oil well in the Yates field, Pecos County, Texas.

The depths of the wells in the Yates field vary from 900 to 1700 ft., depending on surface elevation and the location of the wells on structure. Production rates over 8000 bbl. per hour have been determined and many

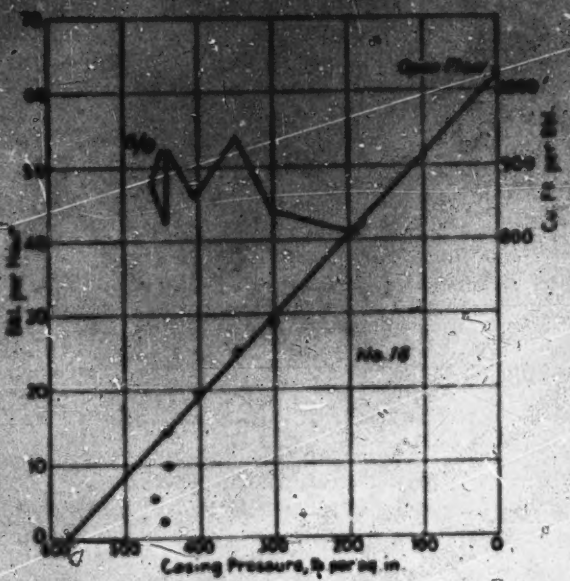


Fig. 1.—Method of determining pressure exerted by column of oil and gas at zero flow.

wells are capable of producing 2000 bbl. hourly. Gas-oil ratios are usually below 400 cu. ft. per barrel, but a few wells high on structure have produced over 3000 cu. ft. per barrel. Incidentally, tubing wells has cut these high ratios to as low as 400 cu. ft.[1] By common agreement of the operators all wells making ratios over 400 cu. ft. will be tubed. Daily production of the field is prorated to 110,000 bbl. from an open-flow potential of 5,000,000 bbl. based on hourly open-flow gages.

* Petroleum Engineer, The Texas Co.

[1] H. H. Hardison: Effects of Tubing Flowing Oil Wells. Galveston Meeting, A. P. I., Sept. 4, 1930.

The bottom-hole pressure has been determined to be 700 lb. per sq. in. gage.

Characteristic production curves for two of these wells are presented in Figs. 1 and 2. The hourly production and the gas-oil ratio are plotted against casinghead pressure. The points, excepting for very small flows, lie in a straight line. The extension of this straight line to zero pressure will give us an accurate estimate of the open flow of the well with all back-pressure removed.[1] This system of obtaining open-flow potentials without actual open-flow tests has been proposed to the operators in the Yates field.

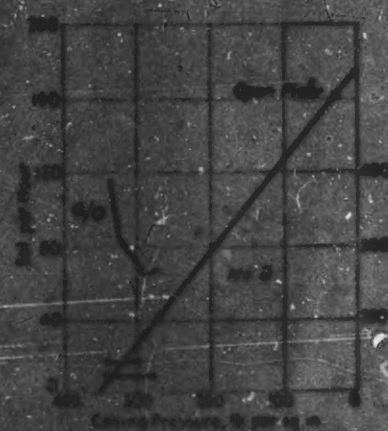


FIG. 2.—METHOD OF DETERMINING PRESSURE EXERTED BY COLUMN OF OIL AND GAS AT ZERO FLOW.

Extending the straight lines in Figs. 1 and 2 in the opposite direction to zero flow gives us a pressure value at zero flow. This pressure is interpreted to be the residual pressure after the pressure exerted by the fluid column is subtracted from the rock or bottom-hole pressure. This pressure is much more significant than a closed-in pressure, for the fluid column has not separated into its component parts, oil and gas, and the value is automatically corrected to zero flow, zero friction and zero work performed on the fluid column. The use of extrapolated values as employed in this method is in general use in engineering and scientific work and is considered applicable in this case.

The subtraction of the shut-in pressure thus found from the measured rock pressure of 700 lb. per sq. in. gives us the pressure exerted by the fluid column (× pressure). Some error is involved by the fact that flow starts somewhere back in the formation and not at measurable points such as the top of the pay or bottom of the hole. Dividing the weight of the fluid column by the distance to the point of entry to the well bore gives us the average weight per foot of the fluid column. The average density of the column can then be calculated. These were calculated on the distance to the top of the first flowing zone and the total depth of the wells.

The data from Figs. 1 and 2 are presented in Table 1; also a summary of the data used and results obtained. Some of these values are obtained from the same well by reason of different trends in different

[1] Yates Pool Committee Proposes Proration Method Based on Rock Pressure. *Pet. Engr.* (January, 1929) 1, 40.

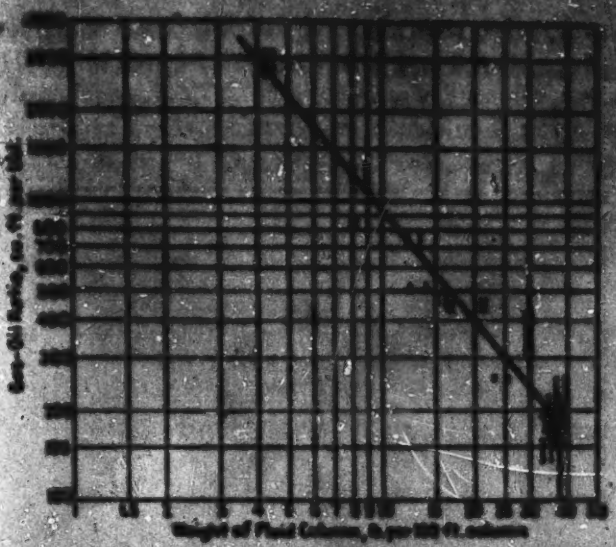


FIG. 2.—WEIGHT OF FLUID COLUMNS OF VARYING GAS-OIL RATIOS.

TABLE 1.—*Summary of Well Data*

Well No.	Oil-gas Ratios	Top Pay	Total Depth	Base Flow Pressure	× Pressure	Calculated Pressure, Lb. per Sq. In. per 100 Ft.		Calculated Density	
						Top Pay	Total Depth	Top Pay	Total Depth
				DATA FROM FIGS. 1 AND 2					
2	810- 940	1435	1510	500	120			0.193	0.183
3	250- 262	1316	1455	365	345			0.606	0.547
				SUMMARY OF DATA USED AND RESULTS OBTAINED					
1	156- 165	1327	1482	180	520	39.2	35.1		
2	150- 200	1280	1367	200	500	39.05	36.6		
3	162- 185	1255	1368	210	490	39.1	35.35		
4	170- 200	1285	1400	220	470	36.6	33.6		
5	198- 200	1285	1400	220	470	37.2	33.6		
6	160- 225	1235	1330	220	470	38.05	35.1		
7	145- 160	1235	1330	260	440	35.65	33.1		
8	250- 262	1316	1455	355	345	28.25	23.7		
9	300- 430	1080	1650	390	310	30.5	29.6		
10	450- 500	1445	1585	495	235	16.27	15.13		
11	700- 800	1675	1844	475	225	13.44	12.20		
12	430- 470	1080	1655	475	225	21.85	21.3		
13	430- 470	1080	1655	525	175	17.0	16.6		
14	510- 530	1145	1290	540	160	13.98	12.40		
15	1150-1300	1675	1844	550	150	8.95	8.13		
16	810- 940	1435	1510	580	120	8.25	7.94		
17	2500-3240	1300	1340	643	57	4.40	4.20		

[illegible] pressure on crude oil [illegible] [illegible] with

[illegible] of gas-oil ratios, thus showing the relationship of the several values [illegible] [illegible] [illegible] 4, 5, [illegible] 6 and 7; 8, 9 and 10; 11 and 12.

The last two columns of pressures in Table 1 are plotted against the gas-oil ratios in Fig. 3 to obtain an average line. This line is terminated at the lower end by the specific gravity of the oil and the upper limit would be determined by the specific gravity of the gas.

Fig. 4.—Average pressure of [illegible] analyses of Yates sands, Penn County.

The average values found are tabulated in Table 2 and presented in Fig. 4.

Table 2.—*Density of Oil-gas Columns*

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	37.6	[illegible]	100
[illegible]	37.6	[illegible]	100
[illegible]	36	[illegible]	95.7
[illegible]	35.9	[illegible]	95.4
[illegible]	35	[illegible]	93.0
[illegible]	35	[illegible]	93.0
[illegible]	34.7	[illegible]	92.3
[illegible]	34.6	[illegible]	92.0
[illegible]	34.6	[illegible]	92.0
[illegible]	34.5	[illegible]	91.7
[illegible]	34.4	[illegible]	91.4
[illegible]	34.3	[illegible]	91.2
[illegible]	34.4	[illegible]	91.4
[illegible]	34.4	[illegible]	91.4
[illegible]	34.3	[illegible]	91.2
[illegible]	34.3	[illegible]	91.2
[illegible]	34.2	[illegible]	91.0
[illegible]	34.1	[illegible]	90.7
[illegible]	34.1	[illegible]	90.7
[illegible]	34.0	[illegible]	90.4
[illegible]	34.0	[illegible]	90.4
[illegible]	34.0	[illegible]	90.4

The data show that between 160 and 200 cu. ft. of gas remain in solution in the oil under pressures of 470 to 520 lb. with very small density changes. A new curve will be found as the rock pressures decrease and less gas is kept in solution in the field underground. Similarly, a lower density would be expected were the gas-lift installed, as the gas would be in the free state at the bottom of the hole instead of in solution, as at present.

Data of this type should be of value in planning gas-lift installations and in estimating bottom-hole pressures. Each field will have its own average density curve, dependent on the depth and nature of the producing formation and the quality of the oil and gas. This method is presented in the expectation that future development and application will make it an active aid in the production of oil and gas.

DISCUSSION

(W. K. Whitford presiding)

T. V. Moore,* Houston, Tex.—Dr. Viett says that the friction losses in the lines in the Yates pool are negligible. I believe one of the curves shown was made from data taken from Humble-Smith A2. On that well, we have found that the friction losses in the formation will amount to 300 lb. per square inch or more. This shows that friction losses in the formation are very important.

Usually, a curve of well-head pressure against production is approximately a straight line at the higher rates of flow. This curve can be extrapolated to zero well-head pressure in order to determine the production under open flow, but I do not quite see Dr. Viett's reason for drawing a straight line through this curve at the lower rates of flow. It can be shown that this curve passes through a maximum point at fairly low rates of production and at lower rates will fall off materially. This type of curve has been observed not only in lime fields but also in fields where the production is taken from unconsolidated sands. Thus, it does not seem to be justifiable to assume that the curve of well-head pressure against production is a straight line at all rates of flow. Experimental work which we have carried on with the gas-lift shows that the average density of a column of oil and gas is dependent as much on the quantity of gas flowing as on the gas-oil ratio. At lower rates of flow, the density of the oil-gas mixture approaches that of the liquid, while at the higher rates the density of the mixture falls off materially. Therefore, the density depends not alone on gas-oil ratio but also on rate of production.

W. V. Vuyet.—Mr. Moore's suggestions are valid inasmuch as the rate of flow does affect the average density of the fluid column. *Low* rates of flow occur when high back-pressures are applied. *Friction* and work are at a minimum; the high pressure causes the oil to retain most of the gas and thus the density of the column approaches that of gas-free oil. Movement of the fluid column is slight and gravity separation of gas and oil occurs. Under higher rates of flow, it is taken for granted that the fluid at the bottom of the column contains little or no free gas, and that the free gas content increases as the fluid nears the top of the hole.

The extrapolation of the straight line back to zero flow does not assume that a well will flow with straight-line characteristics in this region of flow. Friction and

* Production Research Engineer, Humble Oil & Refining Co.

[illegible]

[illegible] decrease in well-head pressures as the rate of flow increases. The pressure drop increases as the rate of flow increases and the backward extrapolation of the line was made with the thought of estimating the density of the field column under steady flowing conditions. No reference is made to the line or densities being valid for low rates of flow under high back-pressures.

The formation in the Yates field is tubular in character and the flow through the formation is more or less of the same nature as that through the flow string. There are two errors in the method presented: (1) We do not know the average distance to the point of field entry; (2) the well field contains much gas in solution under back-pressure. There are errors involved but I do not believe that the method is vitiated by the values actually found under low rates of flow where the back-pressure is keeping practically all of the gas in solution; gravitational separation is occurring and erratic conditions exist. Under these conditions, the density of the field column approaches that of the oil.

T. V. Moore.—There is a very definite reason why that curve passes through a maximum. Pressure losses in the sand increase regularly with production rate. Pressure losses in the flow string at low production rates tend to decrease as production is increased. At higher production rates, friction losses become more important and the pressure losses in the flow string increase with increase in production because the increased friction losses offset the lightening of the column of fluid. The sum of the pressure losses in the flow string and the pressure losses in the sand is, of course, the combined pressure losses from the interior of the reservoir to the well head. It is readily seen that this curve passes through a minimum point which corresponds to the maximum point on the curve of well-head pressure. This is the reason why the curve of well-head pressures rises to a maximum and then falls off.

DEFENDANT'S EXHIBIT L

390

Department of Commerce
United States Patent Office

To all persons to whom these presents shall come,
Greeting:

This Is To Certify that the annexed is a true copy from the records of this office of the Fire Wrapper and Contents, in the matter of the

Pending Application of
Cranford P. Walker,
Filed September 18, 1937, Serial Number 164,534,
for
Improvement in Vibration Translating Means.

In Testimony Whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this twenty-seventh day of March, in the year of our Lord one thousand nine hundred and forty-two and of the Independence of the United States of America the one hundred and sixty-sixth.

(Seal)

CONWAY P. COE
Commissioner of Patents.

Attest:

D. E. WILSON
Chief of Division.

954

PATENT NO.

1937

DATED

(EX'R'S BOOK)

17-13

RENEWED

193

193

193

Defendant's Exhibit L—(Continued)

Mail Division Sep 18 1937 U. S. Patent Office.
Sep 1 18 - 37 051516 D—Check—30.00.

Harold W. Mattingly
Attorney at Law
Patent and Trademark Causes
924 Pacific Finance Building
621 South Hope Street
Los Angeles, California
MAdison 1137
1/84

September 13, 1937.

Commissioner of Patents,
Washington, D. C.

Sir:

Attached is application for Letters Patent of the United Sattes executed September 4, 1937 by Cranford P. Walker for Vibration Translating Means; also attached is my check No. 218 in the amount of $30.00 to cover the Government filing fee (20 claims).

Respectfully,
HAROLD W. MATTINGLY

MM

1/84

Mail Division Sep 18 1937 U. S. Patent Office.
Received Sep 29 1937 Division 5, Paper No.

Defendant's Exhibit L—(Continued)

PETITION

To the Commissioner of Patents:

Your petitioner, Cranford P. Walker, a citizen of the United States, residing at San Marino, in the County of Los Angeles, and the State of California, whose post office address is 2824 Carlaris Road, San Marino, California, prays that Letters Patent may be granted to him for the Vibration Translating Means set forth in the annexed specification, and he hereby appoints

Harold W. Mattingly
924 Pacific Finance Building
621 South Hope Street
Los Angeles, California
(Registry No. 12,385)

his attorney, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.

(Sign here first name in full)

CRANFORD P. WALKER

SPECIFICATION

To All Whom It May Concern:

Be It Known, That I, Cranford P. Walker, a citizen of the United States, residing at San Marino, in the County of Los Angeles, and State of California, have invented certain new and useful

Defendant's Exhibit L—(Continued)

improvements in Vibration Translating Means of which the following is a specification:

1/2

My invention relates to vibration translating means and has particular reference to the reception and translation of pressure waves such as are produced in the echo type of well surveying instruments, to translate the character, form and shape of the received waves or vibrations into graphs or records which may permit the observance and study of the shape, form or character of these waves.

In the measurement of well depths and the location and determination of obstructions of various characters in wells, particularly oil wells, by the pressure wave echo method, a pressure impulse is created in the well, which impulse travels down the well to the various obstructions or constrictions found in the well and is partially reflected by each of them, the reflected waves or echoes traveling back up the well to operate some suitable pressure responsive device which moves or vibrates in response thereto in accordance with the character, amplitude and form of the wave. The echoes or reflections from various different objects encountered within the well produce distinct pressure-time wave patterns for each of the objects or reflecting surfaces and it is desirable to reproduce these wave patterns so that their character, shape, form and relative amplitudes may be observed and studied in order to properly in-

Defendant's Exhibit L—(Continued)

terpret them in terms of nature and character of the reflecting or obstructing devices.

These pressure waves or echoes may be received at the ground surface by mechanical or electrical pressure responsive devices, such as mechanical diaphragms or electrical microphones. It is difficult to construct mechanical receiving devices which will respond with sufficient sensitivity and accuracy to reproduce all of the minute variations in the shape of the wave patterns and conventional electrical microphones, and amplifiers, due to their inability to function with any degree of fidelity where the frequency is below the audible range, have also been found to be inadequate to correctly and completely reproduce the wave patterns in such form as to permit the ready and complete study of the wave patterns.

It is therefore an object of my invention to provide a pressure responsive device which may be used for the reception and translation of the pressure waves, or echoes ~~or other vibrations~~ to accurately reproduce ^ pressure—time wave patterns corresponding in detail with the wave patterns of the ^ pressure wave or echoes. ~~vibrations.~~

Another object of my invention is to provide a pressure responsive device for the reception and translation of vibrations of the character set forth which is extremely sensitive and which faithfully reproduces a wave pattern corresponding to the wave pattern of the vibrations.

Defendant's Exhibit L—(Continued)

Another object of my invention is to provide an electrical system for receiving pressure waves, echoes or other vibrations of the character set forth in which minute variations or changes in the wave patterns described by the vibrations may be received, observed and recorded.

Another object of my invention is to provide a system of the character set forth in the preceding paragraph wherein a novel microphone capable of varying its ∧ electrical impedance is placed in a high frequency tuned circuit adapted to produce a high frequency wave in the nature of a carrier wave and in which the microphone modulates the high frequency current which is then amplified and rectified to operate a direct current galvanometer, oscillograph or other suitable device for accurately indicating and recording the ∧ pressure variations ~~vibrations~~ received by the microphone.

Other objects and advantages of my invention will be apparent from a study of the following specifications, read in connection with the accompanying drawings, wherein

Fig. 1 is a diagrammatic view illustrating the adaptation of my vibration translating mechanism associated with a pressure wave echo well surveying system;

Fig. 2 is a diagrammatic view of one form of electrical circuit which may be employed to translate the pressure variations received ∧ ~~vibrations~~ into observable ∧ pressure-time ~~wave~~ patterns or records;

Defendant's Exhibit L—(Continued)

Fig. 3 is a composite diagrammatic view illustrating the character of the wave patterns which may be reproduced upon a recording chart, compared with the characteristics of the direct current output circuit in accordance with changes in the air gap of the microphone employed in my system;

Fig. 4 is a diagrammatic view of a modified type of circuit which may be employed in the practice of my invention; and

Fig. 5 is a diagrammatic view of a still further modified circuit which may be employed.

Referring to the drawings, I have illustrated my translation system as being associated with a pressure wave echo well surveying device which has now issued as United States Letters Patent No. 2,156,519. such as that illustrated and claimed in my copending application Serial No. 162,699, Filed September 7, 1937.

In Fig. 1 I have illustrated an oil well 1 lined with the usual casing 2 which extends from the ground surface 3 to the bottom of the well. A pump 4 may be located at any desired depth in the well, the pump 4 being usually suspended upon a string of oil flow tubing 5 through which a string of sucker rods 6 extends to operate the moving part of the pump 2, the string of oil flow tubing 5 being usually constructed of a plurality of assembled sections of tubing coupled together by means of couplings 7. A tubing catcher 8 is usually disposed in the string of oil flow tubing. The pump 4 is usually secured to the lower end of the tubing string and lies within a perforated liner 9.

Defendant's Exhibit L—(Continued)

In making a survey to determine the location and character of any of a plurality of obstructions or constrictions of the cross sectional area of the casing 2 or enlargement of the well bore where it is not cased, a pressure impulse of any desired intensity may be introduced into or created within the well casing 2, preferably by either suddenly introducing into the well casing 2 a volume of gas at a pressure higher than the normal gas pressure within the casing 2 or allowing the sudden escape of a volume of the normal gas within the well to create a rarefaction impulse. The method and apparatus for creating the pressure impulse is described in my copending application hereinbefore referred to as consisting essentially of a pressure chamber 10 coupled through a quick opening valve 11 and a pipe 12 to the interior of the casing 2, the pressure chamber 10 being adapted to receive a volume of gas from a suitable tank or source of supply 13 through a ~~quick opening~~ valve 14 until the pressure within the chamber 10 has been built up to a desired value in excess of the value of the normal gas pressure within the casing 2. By then closing valve 14 and quickly opening valve 11, the gas within the chamber 10 may be suddenly released into the casing 2 and create a pressure impulse therein, which impulse partially travels as a pressure wave down the casing 2 and is ^ reflected back by each of the various obstructions within the well, (^C[1]) [Note in margin: Mrs. Scott note that this insertion is D[1]] ~~including the tubing~~

Defendant's Exhibit L—(Continued)

~~collars 7, the tubing catcher 8, and the surface 15 of the fluid within the well, and the top of the liner 9.~~

The pressure impulse and pressure wave may also be created by closing valve 14, opening valve 11 to allow the normal gases within the well to pass into the chamber 10, then closing valve 11 and opening valve 14 to exhaust the gases in the chamber 10 until the pressure therein reaches any predetermined value lower than the pressure within the well. By closing valve 14 and then reopening valve 11 quickly, a volume of the confined gas within the well is allowed to enter the chamber 10, creating a rarefaction impulse which travels down the well and back in the same manner as described for the introduction of pressure into the well.

The reflected impulses or waves, returning up through the casing 2, pass through the pipe 12 to a pressure responsive device 16 which includes a diaphragm 17 exposed to the pressures within the casing 2.

The pressure responsive device in this form of the invention ∧ constituted by ~~constitutes~~ a condenser type microphone, the diaphragm 17 being constructed of a relatively thin sheet of duralumin, the outer edges of which are clamped between a pair of housing members 18 and 19. Disposed in the housing 19 is a mounting block 20 of insulating material, one face of which carries the opposite electrode of the condenser microphone, this electrode being illustrated as a cup-

Defendant's Exhibit L—(Continued)

shaped member 21 of duralumin, the outer face of which is disposed parallel to the plane of the diaphragm 17 and spaced in relatively close juxtaposition thereto.

The housing member 19 forms with the diaphragm 17 a closed chamber 22 and, in order to make the diaphragm 17 sensitive to minute variations in pressure within the casing 2, I prefer to equalize the static pressure within the pipe 12 on both sides of the diaphragm 17 as by providing a somewhat restricted by-pass 23 communicating with the interior of the housing member 18 and with the chamber 22, a suitable filter 24 being interposed in the by-pass if desired to filter and dry the gases to prevent undue corrosion of the parts. A plurality of openings 25 are preferably provided through the electrode 21 and its supporting member 20 to avoid the building up of undesirable pressures between the diaphragm 17 and the electrode 21 by fluctuations of the diaphragm.

The diaphragm 17 may be grounded as indicated at 26 and the electrode 21 may be connected by a suitable wire 27 to an oscillator-amplifier-rectifier indicated generally at 28 and hereinafter more fully described, the output of which may be coupled as indicated at 29 to any suitable indicating or recording device indicated generally at 30. The indicating and recording device may be a recording galvanometer, oscillograph or other suitable device illustrated diagrammatically in Fig. 1 as including a galvanometer 31 which may be arranged to oscillate a mirror

Defendant's Exhibit L—(Continued)

32 receiving light from a suitable source 33 and directing the reflected beam 34 thereof upon a recording tape 35 or upon a suitable screen 36 where the pressure-time movements of the beam, that is, the ∧ wave pattern ~~transmitted by the diaphragm~~, may be observed, studied or recorded.

In the system diagrammatically illustrated in Fig. 1, the light beam 34 has a ribbon-like shape, a reflecting mirror 37 being interposed to intercept a portion of the beam and direct the same through a cylindrical condensing lens 38 upon the screen 36 while the remaining portion of the beam 34 passes through a suitable cylindrical condensing lens 39 to convert the same into a point beam where it may describe the wave pattern upon the tape 35. The tape 35 may be moved relative to the beam 34 in any suitable manner as by a variable speed motor 40 controlled by a rheostat or other device 41.

In view of the fact that the determination of the location of the various obstructions encountered by the pressure wave is made by comparing the wave pattern produced by the echoes from the various obstructions with relation to the time lapse between the creation of the pressure impulse in the casing 2 and the arrival of the echoes at the diaphragm 17, I prefer to describe upon the recording tape 35 a pattern of time lapse indications. One manner in which the same can be done readily is indicated in Fig. 1 as including a synchronous motor 42 arranged to drive an opaque disc 43 having a plurality

Defendant's Exhibit L—(Continued)

of openings 44 therethrough aligned with a light beam 45 from the same light source 33 as was used to produce the beam 34, the openings 44 in the disc being arranged in such manner that during a predetermined time cycle a plurality of dots or marks will be produced by the beam 45 upon the record chart 35, one of the openings 44a being preferably larger than the remainder to make distinguishing marks upon the tape 35 indicitive of the lapse of a multiple of the time units.

With the system just described, the vibrations or movements of the diaphragm 17 relative to the electrode 21 may be utilized to draw upon the chart 35 a faithful wave pattern corresponding to the wave pattern of the echoes received from each of the obstructions in the well, not only the large variations in the pressure but the minute variations thereof which changes the character of the wave form or wave shape.

I prefer the translation mechanism indicated diagrammatically in Fig. 2 as comprising an electrical circuit including a relatively high frequency oscillator circuit A, a tuned amplifier circuit B in which the microphone 17-21 is interposed, an ordinary amplifier circuit C and a rectifier circuit D, producing a direct current output which may be fed

30

directly into the galvanometer 31 or other oscillograph or recording apparatus capable of responding to direct current variations.

Defendant's Exhibit L—(Continued)

In Fig. 2 I have illustrated the oscillator circuit as including an ordinary vacuum tube 50, the grid circuit of which includes a coil 53 and a variable condenser 54 by which the circuit A may be tuned to oscillate at any declared frequency, preferably a moderately high frequency, ranging from approximately 10,000 cycles to 100,000 or more cycles per second, a blocking condenser 54a and a stabilizing resister 54b connecting the grid circuit to the plate circuit in the usual manner.

The output of the tube in circuit B is coupled as indicated at 55a to a standard amplifier circuit C, the microphone 17-21 being included in this circuit and so connected that variations in the air gap between the diaphragm 17 and the electrode 21 will act as a variable condenser. A pair of variable condensers 56 is included in the circuit, one in series with the microphone 17-21, the other in shunt circuit relation to both the microphone 17-21 and the other of these variable condensers and so coupled together that an increase in the ~~reactance~~ capacitance of one of the condensers is accompanied by decrease in the capacitance ~~reactance~~ of the other, ~~the condensers 56 being adjusted to vary the sensitivity of response of the microphone 17-21, as hereinafter more fully described, without changing the tuning of the circuit B.~~ (D^2) A rectifier circuit D, constituting a full wave rectifier, is coupled to the output of the amplifier circuit ~~D~~ C while a direct current measuring or

Defendant's Exhibit L—(Continued)

recording instrument 30 is connected to be supplied with current from the rectifier D. (∧D^3) ~~A variable inductor 57 is included in the output of the circuit B to tune or detune the circuit B to vary the normal steady direct current output from the rectifier to centralize the light beam 34 on the chart 35.~~

output of

The ∧ circuit ∧ B is normally detuned relative to the output frequency of the oscillator A so that variations in the air gap of the microphone 17-21 will tend to tune the circut B or to further detune the same. By tuning the circuit B until the output of the rectifier circuit D is approximately one-half maximum, as indicated by the point g in Fig. 3, on the curve plotted by the direct current output in milliamperes against microphone air gap varia-

straight

tion, the ∧ light beam will describe a line on the chart 35 when the pressure in the well casing 2 is static; that is, the line y on the chart 35 represents the normal position of the beam when no pressure variations are being transmitted to the diaphragm

negative

17. However, a ~~positive~~ ∧ pressure wave striking

open

the diaphragm 17 will ~~close~~ ∧ the air gap of the microphone 17-21, tuning the circuit B closer to the frequency of the oscillator and permitting a higher direct current output in the rectifier D and causing the light beam 34 to describe a peak or wave pattern y^1, the shape and amplitude of which is in correspondence with the shape and amplitude of the wave pattern effecting the microphone. Simi-

Defendant's Exhibit L—(Continued)

positive
larly, a ∧ ~~negative~~ impulse striking the diaphragm 17 will cause a further detuning of the circuit B

deflection
and cause a ∧ ~~fluctuation~~ of the light beam to describe a peak y^{11}. The circuits are so proportioned that the maximum positive and negative deflections of the diaphragm 17 will describe a pattern within

straight line
portion of the
the limits of the points a and b on the ∧ curve x,

lying
that is, ~~lighting~~ ∧ between the limits indicated by dotted lines 58 and 59 on the chart 35.

By properly tuning the circuits A and B, the recorder or indicating instrument 30 may be caused to describe an observable wave pattern identical with the wave pattern received from the various obstructions in the well.

A modified form of circuit which may be employed is indicated in Fig. 4 wherein the microphone 17-21 is inserted in the oscillator circuit A so that any variation in the air gap in the microphone 17-21 varies the output frequency of the oscillator circuit A. The oscillator circuit A is illustrated as being coupled to a tuned amplifier circuit B which will pass more or less current to the rectifier D as the output frequency of the oscillator

resonant
circuit A approaches the ∧ ~~tuned~~ frequency of the circuit B or recedes therefrom. Again the indicating or recording instrument 30 is connected to the

Defendant's Exhibit L—(Continued)

output of the rectifier circuit D to be varied by the direct current output of this circuit.

In Fig. 5 I have illustrated a still further modified circuit which may be employed including a balanced alternating current circuit A which includes an alternating current generator 60 which may be of either the rotary or oscillator type, the output of which is ∧ may be of any desired relatively high frequency, ∧ is coupled to a balanced bridge rectifier circuit E including a pair of half wave rectifier tubes 61 and 62, the tube 61 being connected in one branch of the bridge including the secondary winding of a transformer 63 while the tube 62 is in the other branch including the secondary of the transformer 64. The primary circuit of the transformer 64 includes a variable impedence 65, permitting this circuit to be varied to balance the normal current in the two branches of the bridge, while the primary winding of the transformer 63 is in series with variable impedances 66 and with the microphone 17-21. The recorder or indicator 30 in this form of the device is connected in a shunt circuit extending between the junction of the secondary windings of the transformers 63-64 and the junction between the two rectifiers 61-62.

In this form of the device, when the ∧ combined effect of the impedances of the microphone 17-21 and ∧ its associated variable impedances 66 is equal to that of the variable

Defendant's Exhibit L—(Continued)

impedance 65 ~~are equal~~, the secondary voltages of the transformers 63-64 are equal and there is no potential impressed across the indicator or recorder 30. Any slight variations in the supply voltage or in the frequency supplied by the generator 60 will affect therefore be balanced and will not ∧ ~~effect~~ or be recorded by the recorder 30. A pressure wave or signal impinging upon the diaphragm 17 varies the impedance ∧ ~~thereof,~~ of the microphone 17-21 which in turn unbalances the secondary voltage of the two transformers, resulting in a voltage across the direct current recorder, the direction of which will depend upon whether the impedance of the microphone has been increased or decreased by the signal. (D⁴) The variable condensers 66 may be employed for varying the sensitivity of the microphone without changing the current passing through the transformer 63; that is, the condensers 66 should be so arranged that any increase in the impedance of one is balanced by a corresponding decrease in the impedance of the other.

In each of the circuits described, a reactor 68 and condensers 69 and 70 may be interposed in any portion of the circuits between the microphone and the galvanometer; for example, in the direct current output circuit, if desired, for filtering or for accenting tuning the recorder circuit for the purpose of ∧ periodically recurring ~~amplifying~~ certain of the ∧ echoes received from certain of the obstructions in the well, such as the

Defendant's Exhibit L—(Continued)

echoes received from the tubing colalrs, the frequency of which ranges from 14 to 36 cycles per second. (∧D5) ~~Also, one or more stages of amplification may be added in advance of the recorder 30 for the purpose of amplifying the signals received sufficiently to give a desired fluctuation of the recorder.~~

Patent No. 2,156,519

As is described and claimed in my ∧ ~~copending application~~ hereinbefore referred to, it is important to determine the pressure wave velocity in the particular well under measurement, this velocity being arrived at very readily if the location of one or more of the obstructions in the well is known. Where the location of these obstructions is not known, the velocity of the pressure wave through the particular gaseous medium in the particular well may be readily determined by passing gas from the well casing 2 through a velocity measuring tube 80 as by coupling one end of the tube 80 to the pipe 12 as by means of a pipe 81, the opposite end of the tube 80 being open to the atmostphere as indicated at 82, suitable valves being interposed in the inlet and outlet of the tube 80 to regulate the flow of gas therethrough.

At one end of the tube 80 I provide a diaphragm 83, preferably of magnetic material or in some manner arranged to be vibrated by alternating current supplied to a magnet 84. The alternating current may be supplied through a suitable generator 85 driven by a variable speed motor 86 controlled as to speed by means of a suitable rheostat 87 and pro-

Defendant's Exhibit L—(Continued)

vided with a revolution counter 88 or other indicator which will produce an indication of the frequency of current output of the generator 85 under variable speeds of operation of the motor 86. The voltage and current output of the generator 85 may also be variably controlled as by a rheostat 89.

By supplying current to the magnet 84, the diaphragm 83 may be vibrated at any desired frequency to produce pressure impulses in the tube 80 which will travel along the tube, engaging a diaphragm 17a of a standard microphone or a special microphone similar to microphone 17-21 hereinbefore described. By selecting the frequency of the output of the generator 85 such that a pressure impulse created by the diaphragm 83 will pass to the diaphragm 17a of the microphone and return to the diaphragm 83, synchronized with the production of another impulse by the diaphragm 83, the resulting resonance produced in the tube 80 with the particular gas from the well flowing therethrough may be noted upon a suitable output meter or oscillograph 90, the microphone 17a being coupled through a suitable oscillator-amplifier-rectifier circuit, indicated diagrammatically at 91, similar to any one of those illustrated in Figs. 2, 4 and 5 or through a standard radio type of amplifier. By noting the frequency applied to the diaphragm 83 to obtain resonance and the frequency necessary to apply to the diaphragm 83 to obtain resonance in the tube 80 with air flowing therethrough, a computation of the velocity of

Defendant's Exhibit L—(Continued)

pressure waves in the particular gaseous medium in the well may be readily determined.

While I have illustrated and described herein a condenser type microphone, it will be understood by those skilled in the art that any type of microphone, the impedance of which is varied by the signal or pressure impulses received ~~upon the diaphragm 17~~ thereupon, may be employed.

While I have shown and described the preferred embodiment of my invention, I do not desire to be limited to any of the details of construction shown or described herein, except as defined in the appended claims.

HWM:MM

I CLAIM:

~~1. In a system for producing an observable wave~~ pattern corresponding to an energy wave, a high frequency electric circuit, means in said circuit for receiving the energy wave and for varying the intensity of current in said high frequency circuit in accordance with the wave pattern of said energy wave, means for rectifying the high frequency alternating current into direct current, and a direct current translating device in the output circuit of said rectifier for graphically describing a wave pattern corresponding to the pattern of said energy wave.

2. In a system for receiving and transmitting pressure echoes from a well, a microphone adapted to vary its impedance in correspondence with pressure variations impinging thereon, means for cou-

Defendant's Exhibit L—(Continued)

pling said microphone to said well to expose said microphone to the gas pressures in the well, a source of high frequency current, a high frequency circuit (curre , means coupling said microphone in said high equency circuit to vary the current output of said circuit, and translating means for receiving the output of said circuit and for describing an observable wave pattern described by said output current variation.

3. In a system for receiving and translating pressure echoes from a well, a microphone adapted to vary its impedance in correspondence with pressure variations impinging thereon, means for coupling said microphone to said well to expose said microphone to the gas pressures in the well, a source of high frequency current, a high frequency circuit, means coupling said microphone in said high frequency circuit to act as tuning means tending to tune and detune said circuit relative to said frequency as it is affected by said echoes, to thereby vary the current output of said circuit, and translating means for receiving the output of said circuit and for describing an observable wave pattern described by said output current variation.

4. In a system for receiving and translating pressure echoes from a well, a microphone adapted to vary its impedances in correspondence with pressure variations impinging thereon, means for coupling said microphone to said well to expose said microphone to the gas pressures in the well, a source

Defendant's Exhibit L—(Continued)

of high frequency current, a high frequency circuit, means coupling said microphone in said high frequency circuit to act as tuning means tending to tune and detune said circuit relative to said frequency as it is affected by said echoes, to thereby vary the current output of said circuit, additional tuning means in said high frequency circuit for varying the sensitivity of said circuit to the tuning effects of said microphone, and translating means for receiving the output of said circuit and for describing an observable wave pattern described by said output current variation.

5. In a system for receiving a translating pressure echoes from a well, a microphone adapted to vary its impedance in correspondence with pressure variations impinging thereon, means for coupling said microphone to said well to expose said microphone to the gas pressures in the well, a source of high frequency current, a high frequency circuit, means coupling said microphone in series with the output circuit of said high frequency circuit to act as tuning means tending to tune and detune said circuit relative to said frequency as it is affected by said echoes, to thereby vary the current output of said circuit, and a pair of impedances inversely variable relative to each other, one in series with said microphone and the other shunted across both said microphone and said first impedance, and translating means for receiving the output of said circuit and for describing an observable wave pattern described by said output current variation.

Defendant's Exhibit L—(Continued)

6. In a system for graphically describing an observable wave pattern of a plurality of echoes received from a plurality of different obstructions in a well to permit the ready distinguishment of the echoes received from different obstructions, a microphone the impedance of which is varied by and in accordance with energy waves impinging thereupon, means coupling said microphone to said well to expose said microphone to the pressure waves existing in said well, a high frequency electric circuit, means coupling said microphone to said circuit to vary the intensity of current in said circuit in accordance with vibrations received by said microphone, means for rectifying the output current from said circuit, a direct current translating device coupled to the output of said rectifier for graphically describing a pattern of the waves impinging on said microphone, and means in said high frequency circuit for adjusting the natural period of oscillation of said circuit to produce a direct current output from said rectifier approximately midway between maximum and minimum values when said microphone is subjected only to static pressures.

7. In a system for graphically describing an observable wave pattern of a plurality of echoes received from a plurality of different obstructions in a well to permit the ready distinguishment of the echoes received from different obstructions, a microphone the impedance of which is varied by and in accordance with energy waves impinging thereupon, means coupling said microphone to said well to ex-

Defendant's Exhibit L—(Continued)

pose said microphone to the pressure waves existing in said well, a high frequency electric circuit including said microphone and means for tuning said circuit, means for amplifying and rectifying the current in said high frequency circuit, and a direct current translating device for graphically describing a pattern of the waves impinging on said microphone, whereby adjustment of said tuning means produces a steady direct current output approximately midway between maximum and minimum values when said microphone is subjected to static pressures.

8. In a system for graphically describing an observable wave pattern of a plurality of echoes received from a plurality of different obstructions in a well to permit the ready distinguishment of the echoes received from different obstructions, a microphone the impedance of which is varied by and in accordance with energy waves impinging thereupon, means coupling said microphone to said well to expose said microphone to the pressure waves existing in said well, a high frequency electric circuit including inthe output circuit thereof a reactor, a tuning condenser and said microphone in series relation with each other, and a second tuning condenser connected in series relation with said reactor but in shunt relation across both said microphone and said first condenser, a rectifier for rectifying the output current from said circuit, a direct current translating device coupled to the output of said rectifier for

Defendant's Exhibit L—(Continued)

graphically describing a pattern of the waves impinging on said microphone, and means in said high frequency circuit for adjusting the natural period of oscillation of said circuit to produce a direct current output from said rectifier approximately midway between maximum and minimum values when said microphone is subjected only to static pressures.

9. In a system for graphically describing an observable wave pattern of a plurality of echoes received from a plurality of different obstructions in a well to permit the ready distinguishment of the echoes received from different obstructions, a microphone the impedance of which is varied by and in accordance with the energy waves impinging thereupon, means coupling said microphone to said well to expose said microphone to the pressure waves existing in said well, a high frequency electric circuit having tuning means therein, means connecting said microphone in said high frequency circuit to tune or detune said circuit in accordance with variations of impedance in said microphone, rectifying means for rectifying the output current in said circuit, and a direct current translating device for graphically describing a pattern of the waves impinging on said microphone.

10. In a system for graphically describing an observable wave pattern of a plurality of echoes received from a plurality of different obstructions in a well to permit the ready distinguishment of

Defendant's Exhibit L—(Continued)

the echoes received from different obstructions, a microphone the impedance of which is varied by and in accordance with the energy waves impinging thereupon, means coupling said microphone to said well to expose said microphone to the pressure waves existing in said well, a high frequency electric circuit, means for connecting said microphone in said high frequency circuit to tune or detune said circuit in accordance with variations of impedance in said microphone, rectifying means for rectifying the output current in said circuit, and tuning means in said high frequency circuit adjustable to detune said circuit approximately midway between the tuning and detuning limits thereof by the microphone.

11. In a system for graphically describing an observable wave pattern of a plurality of echoes received from a plurality of different obstructions in a well to permit the ready distinguishment of the echoes received from different obstructions, a microphone the impedance of which is varied by and in accordance with the energy waves impinging thereupon, means coupling said microphone to said well to expose said microphone to the pressure waves existing in said well, a high frequency electric circuit, means for connecting said microphone in said high frequency circuit to tune or detune said circuit in accordance with variations of impedance in said microphone, rectifying means for rectifying the output current in said circuit, tuning means in said high frequency circuit adjustable to detune said cir-

Defendant's Exhibit L—(Continued)

cuit approximately midway between the tuning and detuning limits thereof by the microphone, and one or more stages of amplification interposed between said high frequency circuit and said rectifier.

12. In a system for graphically describing an observable wave pattern of a plurality of echoes received from a plurality of different obstructions in a well to permit the ready distinguishment of the echoes received from different obstructions, a microphone the impedance of which is varied by and in accordance with the energy waves impinging thereupon, means coupling said microphone to said well to expose said microphone to the pressure waves existing in said well, a high frequency electric circuit, means for connecting said microphone in said high frequency circuit to tune or detune said circuit in accordance with variations of impedance in said microphone, ^ full wave rectifying means for rectifying the output current in said circuit, tuning means in said high frequency circuit adjustable to detune said circuit approximately midway between the tuning and detuning limits thereof by the microphone, and one or more stages of amplification interposed between said high frequency circuit and said full wave rectifier.

13. In a system for graphically describing an observable wave pattern of a plurality of echoes received from a plurality of different obstructions in a well to permit the ready distinguishment of the echoes received from different obstructions, a micro-

Defendant's Exhibit L—(Continued)

phone the impedance of which is varied by and in accordance with the energy waves impinging thereupon, means coupling said microphone to said well to expose said microphone to the pressure waves existing in said well, a high frequency electric circuit having tuning means therein, rectifying means for rectifying the output current of said circuit, a high speed direct current galvanometer coupled to said rectifier to be actuated by the direct current output thereof, and means actuated by said galvanometer to describe a pattern of the waves impinging on said microphone.

14. In a system for receiving and translating pressure echoes from a well, a microphone adapted to vary its impedance in correspondence with pressure variations impinging thereon, means for coupling said microphone to said well to expose said microphone to the gas pressures in the well, a source of high frequency current, a high frequency circuit, means coupling said microphone in said high frequency circuit to act as tuning means tending to tune and detune said circuit relative to said frequency as it is affected by said echoes, to thereby vary the current output of said circuit, translating means for receiving the output of said circuit and for describing an observable wave pattern described by said output current variation, and variable filter means interposed between said microphone and said translating means for amplifying response thereof to desirable pressure echoes and minimizing others.

Defendant's Exhibit L—(Continued)

15. In a system for receiving and translating pressure echoes for various obstructions in a well, pressure responsive means coupled to the well to be exposed to pressure variations therein, electrical means actuated by said pressure responsive means to vary electrical values in accordance with the variations of pressure received by said pressure responsive means, translating means for receiving said electrical variations and for describing an observable wave pattern corresponding to the patterns of the echo waves, and means interposed between said pressure responsive means and said translating means for tuning said electrical means to respond more readily to echoes from selected obstructions than to pressure variations emanating from other sources.

16. In a system for receiving and translating pressure echoes from a well, a microphone adapted to vary its impedance in correspondence with pressure variations impinging thereon, means for coupling said microphone to said well to expose said microphone to the gas pressures in the well, a source of high frequency electrical current, means coupling said microphone to said source to vary the frequency in accordance with variation in the pressures impinging thereon, a high frequency amplifier circuit coupled to said source, a rectifier coupled to said amplifier and a direct current translating device in the output circuit of said rectifier to graphically describe a wave pattern corresponding to the pattern of the echo pressure waves, and means for tun-

Defendant's Exhibit L—(Continued)

~~ing said amplifier to the frequency of said source~~ when said microphone ~~is subject~~ only to static pres-~~sure.~~

17. In a system for receiving and translating pressure echoes from a well, a microphone adapted to vary its impedances in correspondence with pressure variations impinging thereon, means for coupling said microphone to said well to expose said microphone to the gas pressures in the well, ~~a source of high frequency current,~~ a balanced bridge circuit including a half wave rectifier in each branch thereof, and a direct current translating device connected across said branches for receiving the unbalanced output of said rectifiers and for describing therefrom a wave pattern corresponding to the pattern of the pressure waves received upon said microphone, ($\wedge B^1$) means coupling said ~~high~~ frequency source to each of said branches, and means interposing said microphone in the coupling to one branch whereby said bridge circuit will be unbalanced in accordance with variations in said pressure waves.

~~18.~~ In a system for determining pressure wave velocity in a given medium, an elongated tube, means for passing the said medium through said tube, means for creating pressure waves in said tube of known frequency including a diaphragm exposed to the interior of said tube, magnetic means for vibrating said diaphragm, a source of variable frequency electric current supplying said magnet,

Defendant's Exhibit L—(Continued)

means for determining the frequency at which said tube resonates including a second diaphragm exposed to the interior of said tube and spaced from said first diaphragm, said diaphragm comprising one element of a microphone, and electrical means for translating vibrations of said second diaphragm in terms of electrical current variations, translating means for receiving said current variations and for describing an observable pattern corresponding to the vibrations received by said second diaphphragm.

~~10.~~ In a system of determining pressure wave velocity in a given medium, an elongated tube, means for passing the said medium through said tube, means for creating pressure waves in said tube of known frequency including a diaphragm exposed to the interior of said tube, magnetic means for vibrating said diaphragm, a source of variable frequency electric current supplying said magnet, means for determining the frequency at which said tube resonates including a second diaphragm exposed to the interior of said tube and spaced from said first diaphragm, said diaphragm comprising one element of a microphone, and electrical means for translating vibrations of said second diaphragm in terms of electrical current variations, translating means coupled to said microphone including a galvanometer movable in correspondence with said current variations, and means for describing an ob-

Defendant's Exhibit L—(Continued)

~~servable pattern of the movements of said galvan-~~ometer.

~~20.~~ A vibrating translating means substantial~~ly as described and shown.~~

Add B^2 C^1 C^7

1/84

In testimony whereof I affix my Signature.

(Sign here first name in full)

CRANFORD P. WALKER

OATH

State of California

County of Los Angeles—ss.

Cranford P. Walker, the above named petitioner, being duly sworn, deposes and says that he is a citizen of the United States, and resident of Marino, California; that he verily believes himself to be the original, first and sole inventor or discoverer of the Vibration Translating Means described and claimed in the annexed specifications; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this application; that said invention has not been patented in any country foreign to the United States on

Defendant's Exhibit L—(Continued)

an application filed by him or his legal representatives or assigns more than twelve months prior to this application; and that no application for patent on said invention has been filed by him or his legal representatives or assigns in any country foreign to the United States ~~except as follows:~~

(Sign here first name in full)

CRANFORD P. WALKER

Subscribed and sworn to before me, this 4th day of September, 1937.

MARJORIE McKAY

Notary Publie in and for the said County and State

My Commission Expires July 14, 1941

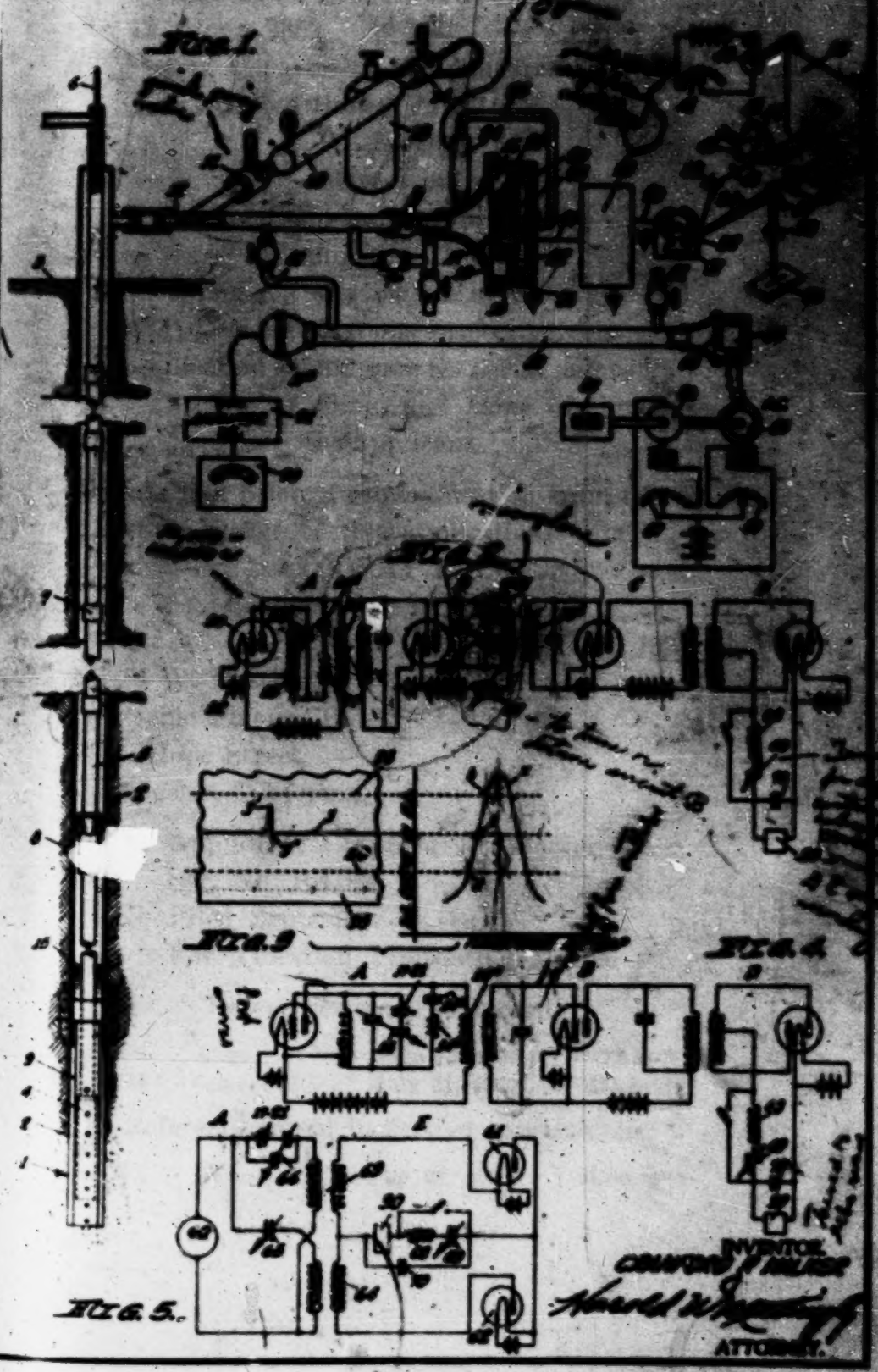
RECEIVED

164534

SEP 29 ...

Division 5. Paper No. 2

Print of drawing as originally filed.



31

164534

Defendant's Exhibit L—(Continued)

Div. 42 Room 5882 260 Paper No. 3

Department of Commerce
United States Patent Office
Washington
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name
All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE,
Commissioner of Patents,

January 17, 1938

Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope Street,
Los Angeles, California.

Applicant: Cranford P. Walker
Ser. No. 164,534
Filed September 18, 1937
For Vibration Translating Means.

References made of record:

2,043,984	Alder	June 16, 1936	73-51(Vib)
2,047,974	Lehr et al	July 21, 1936	177-352(6)

Reference to aid in further prosecution:

2,008,713	Hayes	July 23, 1935	177-352(7)

Defendant's Exhibit L—(Continued)

Division is required between:

I. Claims 2 through 17, which are specific to the species for recording impulses from a well classifiable in class 177, subclass 352, as evidenced by the patent to Lehr et al, and

II. Claims 18 and 19, drawn to a system for determining pressure wave velocity in a given medium classifiable in class 73 as evidenced by the patent to Alder.

These are clearly independent inventions, classifiable in different divisions of the patent office and requiring independent searches.

Claim 1 may be retained with either group since it is a subcombination of both inventions.

Claim 20 is rejected as non-statutory.

There are more claims in the case than the subject-matter justifies. On response, the number should be materially reduced or the patentable difference between each of the claims pointed out.

H. MARANS

Acting Examiner.

LCL

LCL/LM

Defendant's Exhibit L—(Continued)

1/84

Division 42, Paper No. 4a Jul 16 1938 U. S. Patent Office.

Mail Division Jul 15 U. S. Patent Office.

In the United States Patent Office
Division 42
Room 5882

Cranford P. Walker
Vibration Translating Means
Serial No. 164,534
Filed: Setember 18, 1937

Los Angeles, California
July 11, 1938

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In response to the Examiner's letter of January 17, 1938, please amend as follows:

In the specification, page 4, line 17, after "Serial No." insert—162,699—; same line, after "Filed" insert—September 7, 1937—.

Claim 4, line 3, change "impedances" to read—impedance—.

Claim 9, line 14, change "receifying" to —rectifying—.

Claim 12, line 13, before "rectifying" insert—full wave—.

Cancel claims 18, 19 and 20.

[Long hand notation]: Not entered: which rectifying?

Defendant's Exhibit L—(Continued)

REMARKS

In view of the requirement for division, claims 18 and 19 have been canceled, directing all of the claims in this application to the system for receiving and translating wave patterns from the well, classifiable as indicated by the Examiner in Class 177, Sub Class 352.

The Examiner's criticism that there are more claims in this case than the subject matter justifies is not understood. The applicant has provided a novel system for describing a graphic wave pattern corresponding to the waves or vibrations set up in an oil well for the purpose of making certain described measurements in the well. As a part of such system the applicant has provided a novel electric circuit in which the wave form and wave pattern may be drawn with extreme accuracy and fidelity and in so doing he has produced a new and useful result.

The original claims presented in this application were carefully drawn and each of them is directed to a particular feature of the applicant's device and system different from the remaining claims.

Claim 1 is directed broadly to the applicant's system for producing an observable wave pattern which permits him to study such pattern to determine the various measurements denoted thereby, and this claim specifies the employment of a high frequency circuit, means in the circuit for varying the intensity of the current therein "in accordance

Defendant's Exhibit L—(Continued)

with the wave pattern of the energy wave", and to empley a direct current translating device to "graphically describe a wave pattern corresponding to the pattern of the energy wave". In the absence of a reference patent showing this combination, this claim is clearly patentable.

Claim 2 is directed particularly to the applicant's system in which the microphone is exposed to the gas pressures in the well with a circuit which will translate the movements of the microphone into an observable wave pattern. This claim is clearly distinguishable from claim 1.

Claim 3 is more specific in that it defines the coupling of the microphone in the high frequency circuit has a tuner tending to "tune and detune the circuit * * as it is affected by said echoes". This claim is therefore directed to a particular kind of circuit and a particular relationship between the microphone and the circuit.

Claim 4 specifies that the microphone is adapted to vary its impedance in correspondence with the pressure variations impinging thereon and further specifies an "additional tuning means in said high frequency circuit for varying the sensitivity of said circuit to the tuning effects of said microphone". This later is a distinct limitation, distinguishing this claim from any of the previous claims.

Claim 5 specifically describes the coupling of the microphone in "series with the output circuit of said high frequency circuit". This claim further

Defendant's Exhibit L—(Continued)

specifies "a pair of impedances inversely variable relative to each other" and their relationship in the circuit. This claim is more limited than claim 4 and distinguishes from all of the previous claims.

Claim 6 is similar to claims 4 and 5 in that it is directed to the adjustment of the high frequency circuit but it specifies that the adjustment is such as to produce a direct current output approximately midway between maximum and minimum variations "when said microphone is subjected only to static pressures". This is an important feature of the applicant's device in that the static pressure in various wells differs so widely that an adjustment of this character is frequently necessary in order to produce a satisfactory graph or record of the wave pattern which will be produced as a result of the echoes in the well. It is quite obvious that this claim differs from the preceding claims, since it recites a specific limitation directed to a feature not found in preceding claims.

Claim 7 introduces a new element, namely amplifying means for amplifying the small variations in the current so that they may be used to draw an observable wave pattern.

Claim 8 is clearly distinguishable from the previous claims in that it is specific to the characteristics of the microphone and the tuning condensers in the applicant's circuit.

Claim 9 is similar to claim 2 but specifies that the translating device graphically describes the

Defendant's Exhibit L—(Continued)

wave pattern, whereas claim 2 merely requires an observable wave pattern to be produced.

Claim 10 is similar to claim 6 but recites the tuning of the circuit in terms of the tuning and detuning limits of the microphone to permit the adjustment of the circuit to the particular characteristics of the microphone and to the particular characteristics of the microphone as it is affected by the pressures in a given well.

Claim 11 is similar to claim 10 but introduces the fact that several stages of amplification may be interposed between the high frequency circuit and the translation device.

Claim 12 distinguishes from claim 11 by specifying that the rectifier is a full wave rectifier, enabling the applicant to employ the benefit of both sides of the wave to operate the translation device.

Claim 13 is similar to claim 2 but specifies that the translation device includes (a) a high speed galvanometer, and (b) means actuated by the galvanometer to describe the wave pattern.

Claim 14 is similar to claim 2 but includes the further element of a variable filter interposed between the microphone and the translation device to permit amplification of responses to certain echoes and to minimize the response to others, thus permitting the applicant to readily distinguish between echoes from certain characters of obstructions in the well from echoes from other characters of obstructions. This is particularly important as, for example, in measuring and distinguishing the

Defendant's Exhibit L—(Continued)

number of tubing collars from which the applicant may definitely determine the location of a particular obstruction suspended upon or secured to the tubing string or to measure the wave velocity in a particular well under consideration.

Claim 15 is similar to 14 but is broader in that it does not specify the use of a microphone. It does, however, set up all of the necessary elements to describe an observable wave pattern corresponding to the patterns of the echo waves and the means interposed between the pressure responsive means and the translation device for tuning the system to more readily distinguish said types of echoes from others.

Claim 16 is directed to the feature of tuning the amplifier to the frequency of the high frequency source of current which is an important feature of applicant's system.

Claim 17 is specific to the form of the device shown in Fig. 5 describing the balanced bridge circuit employed therein.

In view of the foregoing explanation as to each of the claims, it is believed that the Examiner will find that each of these claims patentably distinguish from each other, and in the absence of references which show that the limitations of one claim over the others is anticipated or lacks invention, each of these claims must be allowed.

The Examiner must keep in mind in examining this application that the applicant herein is licensed under the Lehr et al patent cited by the Examiner

Defendant's Exhibit L—(Continued)

and in working with the system and method described in that patent has added improvements and refinements in the translation mechanism and system to be employed with the apparatus and in the method disclosed by Lehr et al.

The applicant, by employing the circuit and the circuit elements described in this application, is enabled to draw the patterns with such accuracy and fidelity that the wave patterns may be read in terms not only of fluid level, but of the location of other obstructions in the well and by reason of the ability to distinguish between different portions of the wave pattern, the applicant can translate the wave pattern in terms of tubing collars, tubing catchers, liner tops and other obstructions which may be in the well and can determine which portion of the wave pattern is produced by each of these distinguishable obstructions. His system, therefore, is by no means a simple one, nor is it a minor advance over the art. The applicant is therefore entitled to claims adequately covering his invention unless the Examiner can show that the principles of the invention have been already taught by others in the prior art.

It is therefore believed that the number of claims remaining in this application are by no means excessive and that the applicant is at least entitled to an action on the merits of each of them.

Respectfully submitted,

HAROLD W. MATTINGLY
Attorney for Applicant

HWM mm

Defendant's Exhibit L—(Continued)

260

Div. 42 Room 5882

Department of Commerce
United States Patent Office
Washington
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name
Paper No. 5

All communications respecting this application should give the serial number, date of filing, and name of the applicant

Apr 5 1939

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE
Commissioner of Patents,

Harold W. Mattingly
924 Pacific Finance Bldg.
621 S. Hope St.
Los Angeles, Calif.

Applicant: C. P. Walker
Ser. No. 164,534
Filed Sept. 18, 1937
For Vibration Translating means

Under order 2749, no requirements as to matters of form in the drawing, specification or claims will be made until allowable matter is found in the case or appeal is taken.

Defendant's Exhibit L—(Continued)

References added:

1,428,156	Espenschied	Sept. 5, 1922	178-63 (386.6ux
1,650,934	Chubb	Nov. 29, 1927	250-6 (171M1
1,780,567	Rieber	Nov. 4, 1930	177-351 (352.7ux
2,078,796	Greentree et al	Apr. 27, 1937	177-351 (~~18~~ 17

Pertinent art:

1,550,660	Affel	Aug. 25, 1925	179-171 (M2
Bri. 258,946	Rickets (2 sh. 4 pp.)	Oct. 1, 1926	179-171 (M2

Claims 1 through 17a are rejected as indefinite in "a high frequency" since opinions differ as to what constitutes a high frequency. Note that the patent to Rieber calls a frequency of one thousand, a high frequency. It has not been shown that the particular frequency selected is more than a matter of choice and design. If the applicant can show that there is patentable novelty in the selection of the particular frequency used, the claims should set forth the limits, such as a frequency of 10,000-100,000 cycles.

Claim 1 is further rejected on Rieber and Greentree et al. The latter suggests the use of a rectifier in series with the recorder of the former.

Claim 1 is further rejected on Espenschied and Greentree et al. It would not be invention to connect the output of the amplifier for amplifying impulses from a propeller, to a rectifier and a recorder, in view of the common practice of indicating impulses from vibrations by a recorder connected in that way, as evidenced by the patent to Greentree et al.

Defendant's Exhibit L—(Continued)

Claim 1 is further rejected as incomplete in the absence of means for producing a high frequency current in the high frequency circuit. This claim is also incomplete in the absence of structure for amplifying the modulated wave.

Claims 1, 7, 8 and 9 are further rejected as functional in such matter as "for graphically.....said energy wave". Any dire ct current translating device will not perform this function.

Claim 2, line 7, "current" should be --circuit--.

Claims 2, 3, 4, 5, 6 and 14 are rejected as incomplete since they do not include a connection between the source of high frequency current and the high frequency circuit. As claimed the said source is an idle element. These claims are also incomplete in the absence of amplifying means and in the absence of the rectifier. Claim 6 is also incomplete in the absence of the source of high frequency.

Claims 2 and 15 are rejected on Lehr et al and Rieber. It is not invention to use the same structure between the microphone and recroder of Lehr et al, that is used between the corresponding elements of Rieber.

Claim 2 is further rejected on Lehr et al and Espenschied. It is known that the impulse of Lehr et al is of a very low frequency. It is not invention to use an amplifier which is designed to amplify very low frequencies such as that of Espenschied. Note that Rieber tunes his recorder.

Claims 2, 3, 4, 5 and 6 are further rejected since they do not include an antecedent for "current output".

Defendant's Exhibit L—(Continued)

Claims 2 through 13 and 17a are rejected as old combinations on Lehr et al. There is no different combination between I—the well, II—the microphone and the amplifying means and III—the recorder, of the claims than there is between the equivalent elements of the reference. Any novelty is in II and not in the combination. Element II is of general application so its details cannot lend patentability to the combination. Element II should be claimed by itself as evidence by the patent to Espenschied.

Claims 7 through 13 are further rejected as incomplete in the absence of the source of high frequency and its connection to the high frequency circuit. Claims 8, 9, 10 and 13 are also incomplete in the absence of the amplifying means. Claims 10, 11, and 12 are also incomplete in the absence of the recorder. Claim 13 is also incomplete since it does not bring out any relation between the matter before the comma of line 9 and the matter after that comma. Claim 8 does not include an antecedent for "the output circuit".

Claims 14 and 16 are rejected as aggregational. There is no patentable relation between I—the specific modulating means and II—the filter. Each of these operates in the same way in the absence of the other as evidenced by the patents to Chubb and Rieber. Note that Rieber tunes his recording means for the purpose of amplifying certain of the echos from certain obstructions.

Defendant's Exhibit L—(Continued)

Claim 15 is further rejected as incomplete in the absence of the amplifying means and recorder.

Claim 15 is further rejected on Lehr et al alone. This claim differs from the reference only in the inclusion of a filter. But it is not invention broadly to use a filter wherever a filter is desirable.

Claim 16 is further rejected as incomplete in the absence of the relation between the tuning of the amplifier and the different frequencies produced by the source. For instance, if the amplifier were untuned the system would not operate.

H. O. CUTTING
Examiner

LCL
lcl; v

Division 42, Paper No. 6 Oct 3 - 1939 U. S. Patent Office.

Mail Division Oct 2 1939 U. S. Patent Office.

In the United States Patent Office
Division 42 — Room 5882

Cranford P. Walker
Vibration Translating Means
Serial No. 164,534
Filed September 18, 1937

Los Angeles, California
September 29, 1939

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In response to the Office action of April 5, 1939,

Defendant's Exhibit L—(Continued)

please amend the above identified application as follows:

Claim 17, cancel from "a" in Line 6 through "current," in Line 7; Line 13, after the comma, insert

B[1]

—means for supplying a current at a frequency many times greater than the frequency of the pressure echoes desired to be translated,—; same line, cancel "high frequency".

Cancel Claims 1 through 16, inclusive, and substitute the following claims:

B[2]

—21. In a system for receiving and translating pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon to corresponding electrical variations, means coupling said microphone to said well to expose said microphone to gas pressures in the well, a circuit capable of being tuned relative to a selected frequency many times greater than the frequency of the echoes desired to be translated, means supplying said circuit with current at said selected fre-

said circuit including

quency, ∧ ~~means coupling~~ said microphone ~~to said~~

so disposed therein as

~~circuit~~ ∧ to impose the electrical variations produced by said microphone upon the curernt in said circuit, and ~~translating~~ means coupled to said circuit and responsive to variations of current in said circuit

reproduction of

for describing an observable wave pattern ∧ ~~corresponding to~~ the pressure variations in said well.

Defendant's Exhibit L—(Continued)

—22. In a system for receiving and translating pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon to corresponding electrical variations, means coupling said microphone to said well to expose said microphone to the gas pressure in the well, a circuit capable of being tuned relative to a selected frequency many times greater than the frequency of the echoes desired to be translated, means supplying said circuit with a current at said selected frequency, ~~means coupling~~ said circuit including said microphone ~~in said circuit~~ so disposed therein as to act as a tuning means tending to tune and de-tune said circuit relative to said supplied frequency as the circuit is affected ~~it is effected~~ by the electrical variations produced by said echoes, to thereby accordingly vary the current of said circuit, and ~~translating~~ means coupled to said circuit for receiving varying current from said circuit and for describing an observable wave pattern reproduction of ~~corresponding to~~ the pressure variations impinging on said microphone.

~~23. In a system for receiving and translating~~ pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon to corresponding impedance ~~electrical~~ variations, means coupling said microphone to said well to expose said ~~microphone to the gas pressure in the well, a circuit~~

Defendant's Exhibit L—(Continued)

capable of being tuned relative to a selected frequency many times greater than the frequency of the echoes desired to be translated, means supplying said circuit with a current at said selected frequency, ∧ ~~means coupling~~ said microphone ~~in said~~ so disposed therein as ~~circuit~~ ∧ to act as a tuning means tending to tune said circuit including and de-tune said circuit relative to said supplied frequency as it is effected by the electrical variations produced by said echoes, to thereby accordingly vary the current of said circuit, a pair of tuning impedances in said circuit inversely variable relative to each other, one in series with said microphone and the other shunted across both said microphone and said first impedance for varying the tuning effect of the microphone upon said circuit, and ~~translating~~ means coupled to said circuit for receiving varying current from said circuit and for reproduction of describing an observable wave pattern ∧ ~~corresponding to~~ the pressure variations impinging on said microphone.

—24. In a system for receiving and translating pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon to corresponding electrical variations, means coupling said microphone to said well to expose said microphone to the gas pressure in the well, a circuit capable of being tuned relative to a selected frequency many times greater than the frequency of the echoes desired to be translated, means supply-

Defendant's Exhibit L—(Continued)

ing said circuit with a current at said selected frequency, ~~means coupling~~ ∧ said microphone ∧ ~~in said circuit~~ to act as a tuning means tending to tune and de-tune said circuit relative to said supplied frequency as it is effected by the electrical variations produced by said echoes, to thereby accordingly vary the current of said circuit, rectifying means coupled to said circuit to produce a direct current the amplitude of which varies in accordance with the varying current in said circuit, ~~a direct current~~ and responsive to variations in amplitude of said direct current ~~translation device~~ means ∧ coupled to said rectifier ∧ for describing a pattern of the waves impinging on said microphone, and means in said circuit for adjusting the natural period of oscillation of said circuit to produce a direct current from said rectifier approximately midway between maximum and minimum values when said microphone is subjected only to static pressures.

—25. In a system for receiving and translating pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon to corresponding electrical variations, means coupling said microphone to said well to expose said microphone to the gas pressure in the well, a circuit capable of being tuned relative to a selected frequency many times greater than the frequency of the echoes desired to be translated, means supply-

Defendant's Exhibit L—(Continued)

~~ing said circuit with a current at said selected fre-~~
~~said~~ circuit including
quency, ∧ ~~means coupling~~ said microphone ~~in said~~ so disposed therein as
~~circuit~~ ∧ to act as a tuning means tending to tune and de-tune said circuit relative to said supplied frequency as it is effected by the electrical variations produced by said echoes, to thereby accordingly vary the current of said circuit, translating means coupled to said circuit for receiving varying current from said circuit and for describing an reproduction of
observable wave pattern ∧ ~~corresponding to~~ the pressure variations impinging on said microphone, and means interposed between said microphone and said translating means for tuning said sytem to respond more readily to echoes from selected obstructions than to pressure variations emanating from other ~~sources.~~

(Add C1)

REMARKS

Upon a review of the claims of this application in view of the Examiner's criticism of the claims as being incomplete, claims 1 through 16 have been completely redrafted as Claims 21 through 25, particular care being taken in the redrafting of these claims to insure completeness and definiteness of each element recited in the claim.

The Examiner will note that all of the claims remaining in this application are specifically directed to the applicant's system for receiving and

Defendant's Exhibit L—(Continued)

translating pressure echoes from a well so as to describe a line or wave pattern to permit its observation and study and to insure that the observable line or wave pattern will correspond precisely to the pattern of the pressure echoes impinging upon the microphone.

Moreover, one of the important things which is accomplished by the applicant's system is that of accenting certain of the echoes received from the well so as to permit the ready distinguishing of these echoes from other echoes emanating from other sources as well as to permit each individual one of these accented echoes to be distinguished from the others emanating from a similar obstruction in the well.

The applicant is licensed under the Lehr et al patent cited by the Examiner but when applicant attempted to use the mere microphone amplifier recorder construction as shown and described in this patent, he found that in many instances the graphic recording which was received required an expert study thereof by persons having considerable experience in the reading of such records in order to permit such person to distinguish and recognize the recordings of the echoes from different obstructions in the well. For example, tubing catchers, one or more of which may be located upon the string of flow tubing above the surface of the fluid, would produce echoes which would graphically record upon the chart in much the same manner as the echo back from the fluid surface. Echoes from the collars

Defendant's Exhibit L—(Continued)

which interconnect the adjacent sections of the tubing string would produce waves on the record chart but which would be so intermingled with reverberations and echoes produced by other obstructions in the well such as the space between adjacent sections of the casing at the joints thereof or tubercules which might be upon the interior surface of the casing or perforations in the casing, so that it was exeremely difficult to distinguish the recordings of echoes from the tubing collars and other disturbance vibrations.

One of the important things discovered by this applicant was that instead of attempting to mathematically calculate the velocity of the pressure waves through the gaseous medium in the well and to thereby compensate for the total time period elapsing between the production of the pressure impulse and the arrival at the ground surface in different wells under measurement (and the velocity of sound or pressure waves in oil wells varies over wide limits between different wells though they may be located in the same field and may be expected to have the same character of gas, the same density of gas and the same temperature of gas) he could directly measure same.

The applicant conceived the idea that if he could produce a translating system which could receive the pressure variations in the well resulting from the echoes from the various obstructions in the well and draw an accurate picture of these pressure vari-

Defendant's Exhibit L—(Continued)

ations, he would find that the picture or record of an echo from one kind of obstruction would be different from the record of an echo from a different kind of obstruction and that he could therefore in any chart distinguish the echoes from different obstructions from each other. Particularly he desired to record the echoes from successive tubing collars so as to simplify a fluid level determination by merely counting up the tubing collar echoes and multiplying them by the known length of each section of pipe with which the tubing string is constructed.

An additional discovery was made by the inventor, namely, that with a receiving and translation system which would be entirely accurate for one well would not be entirely accurate nor draw a favorable reproduction of the pressure echoes when applied to another well but that something was necessary to permit a ready adjustment of the translation system to different wells in order to achieve this purpose. For example, in one well it was necessary to de-sensitize the microphone or the effect of the microphone upon the translation system while in other wells it was impossible to get good readable results unless the microphone was rendered extremely sensitive or the system was rendered extremely sensitive to the effects produced by the microphone.

He therefore devised, not merely a system of beating or modulating or adding one current to another, as did Rieber and Espenschied and Greentree, but

Defendant's Exhibit L—(Continued)

he produced a system peculiarly adapted to the problem he was attempting to solve, namely, how to draw an observable wave pattern which would be an accurate and favorable reproduction of the wave patterns in the well.

It is therefore contended that the applicant has made an advance in the art of receiving and translating pressure echoes from a well which is not the mere production of a new element in an old combination but is instead a new and patentable combination.

Lehr et al disclose a system for producing an impulse in a well and for receiving and recording pressure echoes emanating from the well. The applicant is not claiming this combination in this case but instead he is claiming a combination of electrical elements which permits a microphone and a registering or recording device to be employed to accurately reproduce the varying pressure conditions existing in the well.

This combination comprises at least three essential elements: (1) a microphone; (2) a circuit and the manner in which that microphone is connected in that circuit to produce electrical variations corresponding to the variations of pressure in the well; and (3) a translation or recording device which can receive the varying electrical values in the circuit and describe the observable wave pattern. The applicant utilizes these three elements in a manner and mode of operation which is distinct from the

Defendant's Exhibit L—(Continued)

manner and mode of operation employed in the microphone and recorder of Lehr et al. At this point it should be noted that Lehr's amplifier is not an element in the Lehr system which corresponds to the applicant's circuit and source of high frequency for the reason that applicant's circuit and source of high frequency are not used merely to amplify the movements of the microphone but are employed to translate the movements of the microphone with a fidelity impossible to be achieved by any amplification.

It is believed therefore that the Examiner's rejection of claims in this application on the ground of old combination is not well taken since such rejection must be based upon a finding in the prior art of the same or equivalent elements cooperating in the same manner or mode of operation to produce the same result. Neither the result nor the mode of operation nor the elements disclosed by the applicant are found in Lehr et al.

New Claim 21, which represents old Claim 2 rewritten to avoid formal objections, now defines the applicant's system in terms which clearly distinguish it from Lehr et al or from any combination of Lehr plus Rieber. This claim defines the use of the microphone exposed to the well to respond to pressure variations in the well, a circuit into which said microphone is coupled and to which circuit a source of current in a known frequency many times greater than that of the echoes desired to be trans-

Defendant's Exhibit L—(Continued)

lated so as to produce for the translation device an accurate reproduction of the pressure waves impinging on the microphone.

Lehr et al do not show this general combination and the substitution of the Rieber system for the Lehr amplifier would not satisfy the terms of this claim, even though such substitution could be made without invention, for the reason that this claim specifies supplying to the circuit a current of a frequency many times greater than the frequency of the echoes desired to be translated. Rieber, on the other hand, produces from his measuring instrument a high frequency and then combines this with a low frequency added to his circuit. The applicant here was faced with a problem of reproducing low frequency acoustical vibrations and none of the teaching of the Rieber patent would assist him in determining how to achieve the result he obtains.

Moreover, the teaching of the Rieber patent is by no means so obvious as to suggest its use or to suggest how it could be used in the Lehr system to produce the results obtained by the applicant. It is only after the Examiner has seen the disclosure of the applicant's system that he is able in his imagination to try to supply the deficiencies of Lehr as a reference against the applicant by seeking in some other patent a circuit which he considers bears some resemblance to the applicant's circuit.

It is believed that upon reconsideration the rejection based upon the combination of Lehr et al and Rieber will be withdrawn.

Defendant's Exhibit L—(Continued)

New Claim 22 is substituted for old Claim 3 and defines the applicant's circuit which is capable of being tuned to a selected frequency and supplied with that selected frequency and which has the microphone so connected therein as to tune and detune the circuit to that selected frequency depending upon variations of pressure impulses impinging upon the microphone.

It is noted that in the previous Office action the subject matter of this claim was rejected only on the ground that it was directed to old combination. In view of the foregoing remarks with regard to old combination, and in addition to the fact that this claim defines a peculiar relation between the microphone and its effect upon the circuit, it is believed that the Examiner will find the subject matter of this claim allowable.

New Claim 23 represents old Claim 4 rewritten, this claim defining the same subject matter as Claim 22, but with the addition of an additional tuning means in the circuit which allows the sensitivity of this circuit to the tuning effects of the microphone to be adjusted and varied so as to readily allow the translation system to be adapted to the acoustical conditions existing in a particular well under measurement. This is subject matter not found in any of the references and introduces an element which further distinguishes this claim as a new combination from any combination shown in Lehr et al.

New Claim 24 represents old Claim 5 rewritten. This claim is similar to Claim 23 but specifies the

Defendant's Exhibit L—(Continued)

tuning means in the circuit as constituting a pair of tuning impedances inversely variable relative to each other and specifies the manner of their connection in the circuit with reference to each other and to the microphone. This claim is clearly allowable.

New Claim 25 is old Claim 15 rewritten to present this subject matter in better form and includes the subject matter of Claim 22 with the additional element of variably tuning the system to render it peculiarly responsive to selected echoes. This defines the structure by which the applicant secures the important result of being able to so accent the tubing collar echoes as to make the record of each one of them stand out individually so that they can be distinguished one from the other as well as distinguished from echoes from other obstructions. This is more than any mere inclusion of a filter which would tend to filter out some objectionable vibrations but instead provides necessary mechanism for increasing the sensitivity of the circuit to these peculiar vibrations and to produce a more clearly readable record therefrom.

It is believed that upon reconsideration this claim will likewise be found allowable over any of the references of record.

Reconsideration of Claim 17 as amended is requested, this claim now avoiding the formal deficiencies of this claim. This claim is directed to a particular balanced bridge circuit which may be

Defendant's Exhibit L—(Continued)

employed as one species of system and which is not suggested by any of the references or any combination of them.

In making the foregoing amendment, a sincere attempt has been made to meet each and every of the rejections and objections made by the Examiner particularly to point out why the applicant's system as presented in these claims is not a mere recital of an old combination but is in fact the recital of a new combination of elements to produce a new result.

It is believed that upon reconsideration each and every of the claims now presented will be found allowable and an early favorable action is respectfully requested.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant

HWM:MM

Defendant's Exhibit L—(Continued)

260

Div. 42 Room 5882

Department of Commerce
United States Patent Office
Washington
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name

Paper No. 7

All communications respecting this application should give the serial number, date of filing, and name of the applicant

Apr 22 1940

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE
Commissioner of Patents,

Harold W. Mattingly
924 Pacific Finance Bldg.
621 S. Hope St.
Los Angeles, California

Applicant: Cranford P. Walker
Ser. No. 164,534
Filed Sept. 18, 1937
For Vibration Translating Means

Responsive to the amendment filed October 2, 1939.

In line 15 of page 11, "D" should be C.

Defendant's Exhibit L—(Continued)

The description of Fig. 5 is believed to be inaccurate in the last three lines of page 13. Assuming that the inpedances of the coils 63 and 64 are equal, then the two branches can not be balanced if the impedence of the microphone 17-21 and that of impedance 65 are made equal. A balanced condition requires that both branches be tuned to the same frequency; accordingly, impedance 65 should be made equal to the combined impedance of the microphone 17-21 and the condensers 66.

Furthermore, applicant has not stated how the branches are tuned with respect to generator 60. Are these circuits, like the input of amplifier B in Fig. 3, tuned to the (normal) frequency of the oscillator or are they, like the output of the amplifier B in Fig. 2, detuned with respect to the oscillator?

Claim 17 is specific to Fig. 5. New claims 21 through 25 are indefinite, but so far as they are clear they are believed to be specific to Fig. 2. Unless applicant can show that one or more of the claims is generic, or that all of the claims are readable on Fig. 5, division will be necessary between claim 17 and the remaining claims. In the event applicant considers claims 21-25 to cover the species disclosed in Fig. 5 he is requested to read claims 21-25 on that figure.

In Fig. 4 the circuit of amplifier B is tuned to the normal frequency of the oscillator, and variation of the microphone does not vary its tuning but merely changes the efficiency of energy transfer to it. Accordingly claims 21 through 25, calling for a circuit

Defendant's Exhibit L—(Continued)

coupled to the generator which is capable of being tuned, are not readable on Fig. 3.

In Fig. 5 circuit E is not tunable as claimed, and the examiner is not able to read the claims clearly on Fig. 5.

Presumably, therefore, the tunable output circuit of amplifier B in Fig. 2 is the "circuit" of line 6, and claims 21-25 are intended to read on Fig. 2.

Claim 2 is rejected as being inaccurate since the microphone is not connected to the tunable output of amplifier B but is connected in it, forming part of it. That is, the capacity of the microphone plays a part in the tuning of the "circuit" of line 6 even when the microphone is not receiving a pressure wave.

Claim 21 would be in better form if it were revised to make clear that "the means coupling the microphone to the said circuit to impose electrical variations....." is not a separate and distinct element, but is in fact a part of the "circuit" of line 6. This same objection applies also to claims 22, 23, 24 and 25.

Claims 21 through 25 are rejected as being functional in the last four lines. "Translating means" do not necessarily perform the function set out in the last four lines. The objection can be avoided by canceling "translating", so that the functional statement will define the "means" instead of serving merely to recite an additional function for it beyond its "translating" function.

Defendant's Exhibit L—(Continued)

Claims 21 through 25 are rejected as being indefinite in the use of the words "corresponding to" (e.g. line 15 of claim 21) and to this extent failing to define the invention with the particularity required by the statutes. The translating means must describe a wave pattern which reproduces the variations present in the pressure wave. It is not enough that the recorded wave pattern shall "correspond" to the pressure waves—in the Lehr system, the recorded wave pattern "corresponds" (e.g., in time of arrival, frequency of occurrence, maximum amplitude, etc.) to the pressure wave in the well.

This case is believed to contain patentable subject-matter. The above explanations are made to indicate the features which, in the examiner's opinion, must be incorporated into the claims in order properly to define that subject matter.

H. O. CUTTING
Examiner

J.D.S.
JDS/ec

Defendant's Exhibit L—(Continued)

Division 42, Paper No. 8 Oct 21 1940 U. S. Patent Office.

In the United States Patent Office
Division 42 — Room 5882
Via Air Mail
Confirmation
Regular Mail

Mail Division Oct 19 1940 U. S. Patent Office.

Cranford P. Walker
Vibration Translating Means
Serial No. 164,534
Filed September 18, 1937

Los Angeles, California
October 17, 1940

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In response to the Office action of April 22, 1940, please amend the above identified application as follows:-

Page 11, Line 15, change "D" to read —C—; Line 30, before "line" insert —straight—.

Page 12, Line 17, before "curve" insert —straight lineportion of the—; Line 18, change "lighting" to read —lying—.

Page 13, Line 28, before "imped-" insert —combined effect of the—; Line 29, after "and" insert —its associated variable impedances 66 is equal to—; Line 30, cancel "are equal".

Page 14, Line 5, change "effect" to read

Defendant's Exhibit L—(Continued)

—affect—; Line 7, change "thereof" to read —of the microphone 17-21—.

Claim 21, Line 10, cancel "means coupling" and substitute —said circuit including—; same line, cancel "to said circuit" and substitute —so disposed therein as—; Lines 12 and 13, cancel "translating"; Line 15, change "corresponding to" to read —reproduction of—.

Claim 22, Line 10, cancel "means coupling" and substitute —said circuit including—; same line, cancel "in said circuit" and substitute —so disposed therein as—; Line 12, cancel "it is effected" and substitute —the circuit is affected—; Line 15, cancel "translating"; Line 17, cancel "corresponding to" and substitute —reproduction of—.

Claim 23, Line 4, change "electrical" to read —impedance—; Line 10, cancel "means coupling" and substitute —said circuit including—; cancel from "in" in Line 10 through "circuit" in Line 11 and substitute —so disposed therein as—; Line 20, cancel "translating"; Line 22, change "corresponding to" to read —reproduction of—.

Claim 24, Line 10, cancel "means coupling" and substitute —said circuit including—; same line cancel "in said circuit" and substitute —so disposed therein as—; Line 18, cancel "a direct current translation device" and substitute —means—; Line 19, after "rectifier" insert —and responsive to variations in amplitude of said direct current—.

Claim 25, Line 10, cancel "means coupling" and substitute —said circuit including—; cancel from

Defendant's Exhibit L—(Continued)

"in" in Line 10 through "circuit" in Line 11 and substitute —so disposed therein as—; Line 17, change "corresponding to" to read —reproduction of—.

Add the following claims:

C1

—26. In a system for receiving and translating pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon to corresponding impedance variations, means coupling said microphone to said well to expose said microphone to gas pressure in the well, a circuit including a source of alternating current of a frequency many times greater than the frequency of the echoes desired to be translated, said circuit including said microphone so disposed therein as to vary the alternating current therein in accordance with pressure variations impinging on said microphone, and means coupled to said circuit and responsive to variations of said alternating current in said circuit for describing an observable wave pattern reproduction of the pressure variations in said well.

—27. In a system for receiving and translating pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon to corresponding impedance variations, means coupling said microphone to said well to expose said microphone to gas pressure in the well, a circuit including a source of alternating current of a fre-

Defendant's Exhibit L—(Continued)

quency many times greater than the frequency of the echoes desired to be translated, said circuit including said microphone so disposed therein as to vary the impedance of said circuit and to thereby vary said alternating current in accordance with the pressure variations impinging on said microphone, and means coupled to said circuit and responsive to said alternating current in said circuit for describing an observable wave pattern reproduction of the pressure variations in said well.

—28. In a system for receiving and translating pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon to corresponding impedance variations, means coupling said microphone to said well to expose said microphone to gas pressure in the well, a circuit including a source of alternating current of a frequency many times greater than the frequency of the echoes desired to be translated, said circuit including said microphone so disposed therein as to vary the impedance of said circuit and to thereby vary said alternating current in accordance with the pressure variations impinging on said microphone, a pair of impedances in said circuit inversely variable relative to each other, one in series with said microphone and the other shunted across both said microphone and said first impedance for varying the effect of the microphone on said circuit, and means coupled to said circuit and responsive to variations of said alternating current in said circuit for describing an observ-

Defendant's Exhibit L—(Continued)

able wave pattern reproduction of the pressure variations in said well.

—29. In a system for receiving and translating pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon to corresponding impedance variations, means coupling said microphone to said well to expose said microphone to gas pressure in the well, a circuit including a source of alternating current of a frequency many times greater than the frequency of the echoes desired to be translated, said circuit including said microphone so disposed therein as to vary the impedance of said circuit and to thereby vary said ~~said~~ alternating current in accordance with the pressure variations impinging on said microphone, means coupled to said circuit and responsive to variations of said alternating current in said circuit for describing an observable wave pattern reproduction of the pressure variations in said well, electrical echo accenting and ∧ means interposed between said microphone causing and said last named means for ~~tuning~~ ∧ said system periodically recurring to respond more readily to ∧ echoes from ~~selected obstructions~~ (∧D^6) than to pressure variations emanating from other sources.

30. In a system for receiving and translating pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon to corresponding impedance variations, means

Defendant's Exhibit L—(Continued)

coupling said microphone to said well to expose said microphone to gas pressure in the well, a tunable circuit including a source of alternating current of a frequency many times greater than the frequency of the echoes desired to be translated, another tunable circuit coupled thereto, said microphone being so disposed in one of said circuits to act as a tuning means therefor tending to tune and detune said circuits relative to each other as the circuit including the microphone is affected by the microphone variations produced by said echoes, to thereby accordingly vary the alternating current in said circuits, and means coupled to said circuits and responsive to variations of said alternating current in said circuits for describing an observable wave pattern reproduction of the pressure variations in said well.—

REMARKS

The Examiners' suggestions in connection with the specification and claims of this application are sincerely appreciated and have been incorporated into the specification and claims as now amended.

The description of Fig. 5 in the last three lines of Page 13 has been corrected so as to recite the fact that the combined impedances of the microphone and variable impedances 66 is equal to the impedance 65.

However, the question raised by the Examiner as to whether or not the two branch circuits in Fig. 5 are tuned with respect to the generator 60 is be-

Defendant's Exhibit L—(Continued)

lieved to be best answered by the statement that they do not have to be balanced in order to be operative though it is true that if they are so tuned small variations in pressure will produce a relatively greater affect in the circuit and under some conditions this sensitivity might be desirable. However, such high ratio of response may not be particularly desirable especially when the system is used upon wells in which reverberations and disturbance echoes are to be separated from desired tubing collar echoes from actual obstructions in the well, under which conditions it is desirable that only the larger pressure variations are desired to be effective upon a system.

In Claims 21 through 25 the microphone is positively recited as being located in the circuit, thus avoiding the inference that there is a separate element required to couple the microphone to the circuit. Also each of these claims has been amended by cancelling the objectionable expression "translating" in accordance with the Examiner's suggestion.

Claims 21, 22, 23 and 25 have been amended to describe the observable wave pattern as a "reproduction of" the pressure variations impinging on the microphone or the pressure variations existing in the well, thus avoiding the criticism noted by the Examiner on the grounds of functionality and indefiniteness. This latter criticism, however, did not apply to Claim 24.

Defendant's Exhibit L—(Continued)

The Examiner's criticism of Claim 2 is not understood since in the amendment of October 2, 1939 instructions were given to cancel Claims 1 through 16 and if Claim 2 has not been cancelled, this will be the authority of the Examiner to cancel this claim.

With regard to the Examiner's discussion of the species defined in Claims 21 through 25 and in Claim 17, it was believed that Claims 21 through 25 as originally presented were readable upon all of the three forms of the invention shown and described in this application. However, upon reviewing these claims, it appears that the Examiner is correct and these claims will read only upon the form of the invention illustrated in Fig. 2.

For this reason new Claims 26 through 30 are presented herewith, Claims 26, 27, 28 and 29 having been carefully drawn to include within their terms expressions which are generic to all of the three species of invention.

Claim 26 defines the employment of the source of high frequency in connection with the circuit which includes the microphone so arranged that the microphone will "vary the alternating current" in the circuit in accordance with pressure variations impinging upon the microphone. This expression will read equally as well upon Fig. 2 as upon Fig. 4 and Fig. 5, in each of which claims of the invention the affect of pressure waves on the microphone is to vary the alternating current in the circuit in accordance with the pressure variations.

Defendant's Exhibit L—(Continued)

In Fig. 2 the affect of the microphone is to vary the amplitude of the alternating current frequency; in Fig. 4 the affect of the microphone is to vary the frequency of the alternating current source and thus produce in the portion B of the circuit an alternating current whose amplitude is in correspondence with the pressures impinging upon the microphone; in Fig. 5 the affect of the microphone is to vary the alternating current in the portion A of the circuit in accordance with the pressure variations and thus produce in the portion E of the circuit a "varying alternating current" which ultimately results in the bridge circuit in producing a direct current, the amplitude of which corresponds to the pressure on the microphone.

New Claim 30 is presented as being generic to the forms of the applicant's system shown in Fig. 2 and Fig. 4, this claim rectifying the fact that there are two circuits, both tunable, and the microphone as being located in one of the circuits so as to tune and detune that circuit relative to the other to accomplish the result set forth.

Each of the new Claims 26 through 30 is clearly allowable over any of the references of record and being generic the applicant is entitled in this application to separate species claims such as Claims 21 through 25 specific to Fig. 2, and Claim 17 specific to Fig. 5, and Claim 30 which is specific only to Figs. 2 and 4.

Defendant's Exhibit L—(Continued)

It is believed therefore that each of the claims now presented is properly allowable in this application and an early favorable action is respectfully requested.

Respectfully submitted,
HAROLD W. MATTINGLY
Attorney for Applicant

HWM:MM

1/84

Mail Division Dec 23 1940 U. S. Patent Office.
Division 42, Paper No. 8 Dec. 26 1940 U. S. Patent Office

In the United States Patent Office
Division 42 Room 5882

Cranford P. Walker
Vibration Translating Means
Filed September 18, 1937
Serial No. 164,534

SUPPLEMENTAL AMENDMENT

Los Angeles, California
December 18, 1940

Commissioner of Patents
Washington, D. C.

Sir:

Supplementing the amendment of October 17, 1940, please amend the above identified application as follows:

Page 1, Line 15, before "reflected" insert—par-

Defendant's Exhibit L—(Continued)

tially—; same line, before "them" insert—each of —; Line 22, after "distinct" insert—pressure-time—.

Page 2, Line 17, change the comma to read—or —; Line 18, cancel "or other vibrations"; same line, before "wave" insert—pressure-time—; Line 20, change "vibrations" to read—pressure wave or echoes—.

Page 3, Line 7, before "impedance" insert—electrical—; Lines 14 and 25, change "vibrations" to read—pressure variations—; Line 25, before "wave" insert—pressure-time—.

Page 4, Line 18, before the period, insert—which has now issued as United States Letters Patent No. 2,156,519—

Page 5, Line 2, change "2" to read—4—; Line 27, cancel "quick opening".

Page 6, Line 5, before "reflected" insert—partially—; cancel from "including" in Line 6 through the period in Line 9 and substitute

D1

—such as the tubing collars 7, the tubing catcher 8, the top of the liner 9 or any other obstruction which may be in the well and exposed above the fluid surface as well as partially reflected back by the surface 15 of the fluid within the well.—

Page 7, Line 2, change "constitutes" to read—is constituted by—.

Page 8, Line 15, before "wave" insert—pressure-time—; Lines 15 and 16, cancel "transmitted by the diaphragm".

Defendant's Exhibit L—(Continued)

Page 10, Line 11, change "31" to read—30—.

Page 11, Lines 8 and 9, change "reactance" in both instances to read—capacitance—; Line 10, after "other" insert a period; cancel from "the" (second occurrence) in Line 10 through the period in Line 13 and substitute the following:

D2

—The condensers 56 are so arranged that the net capacitance of the network made up of condensers 56 and microphone 17-21 remains unchanged with adjustment of condensers 56. Since a decrease of the capacitance of the series part and an increase of the capacitance of the shunt part of condenser group 56 reduces the effect of microphone capacitance variation upon the net capacitance variation of the network, it is possible to adjust for pressure variation levels occurring under various circumstances. This allows operation of the associated carrier amplifier and recording equipment at an optimum level. The condensers 56 when so arranged do not affect the static tuning of the circuits with which they are associated—;

Cancel from "A" in Line 17 through the period in Line 21 and substitute

D3

—The direct current input to the recorder 30 is preferably adjusted to approximately one-half of its full scale value when no echoes are being received by the microphone as by adjusting the frequency of the oscillator circuit A or by adjusting the tuning of the amplifier circuit B so that the

Defendant's Exhibit L—(Continued)

normal steady direct current supplied to the recorder 30 will centralize the light beam 34 on the chart 35.—; Line 22, before "circuit" insert—output—, and after "circuit" insert—of—.

Page 12, Line 4, change "positive" to read—negative—; Line 5, change "close" to read—open—; Line 11, change "negative" to read—positive—; Line 13, change "fluctuation" to read—deflection—.

Page 13, Line 2, change "tuned" to read—resonant—; Line 12, cancel "is" and substitute—may be —; same line, after the comma insert—is—.

Page 14, Line 12, after the period insert

D4

—In the usual form of this system, the circuits are preferably not tuned with respect to the high frequency carrier source. Sufficient sensitivity is available when the circuit is operated close to balance. Proper impedance matching of the bridge to the oscillator and recording circuit and utilization of the power capabilities of the circuit permit operation without amplification. Tuning of the coupling transformers 63 and 64 with their associated condenser circuits to the generator 60 frequency so that the variations of the microphone capacitance cause both bridge unbalance and microphone circuit tuning or detuning results in higher sensitivity but circuit adjustments when using such tuned arrangement are more difficult.

D5

Line 24, change "amplifying" to read—accenting

Defendant's Exhibit L—(Continued)

—; Line 25, before "echoes" insert—periodically recurring—; Line 28, cancel from "Also" to the end of the page and insert the following paragraphs:

D5

—Under some conditions encountered in wells a series of reflections from periodically occurring obstructions become obscure on the part of the record corresponding to the lower portion of the well due to excessive attenuation, oscillations in the instrument piping, reverberations in the well or to undesired echoes from pipe joints. The depth in the well to which these periodically occurring reflections can be recorded can be greatly increased through tuning of the recording circuit to a frequency corresponding to the number of collar or pipe joint echoes received per second. Narrowing of the frequency band recorded by the galvanometer in tuning, although depreciating the record detail, readily permits locating the well fluid level with respect to collars down to the fluid. The sharpness of tuning determines the attenuation characteristic so that the wave shape of the received reflections need not be smoothed any more than necessary in order to bring the desired periodic reflection series up out of the background. In all cases the tuning is highly damped in order to prevent false records from shock excitation.

—However, in order to permit the study of the particular wave forms of the echoes from the different obstructions, it is desirable to record the

Defendant's Exhibit L—(Continued)

echoes without the accenting of the periodically recurring echoes from the tubing collars or pipe joints, which accenting tends to somewhat distort the precise wave pattern and for this purpose a switch S may be provided in a shunt circuit extending about the reactance 68 and condenser 69 which will when closed eliminate from the system the tuning or accenting effects.

—Also one or more stages of amplification may be added in advance of the recorder 30 for the purpose of amplifying the signals received sufficiently to give a desired fluctuation of the recording beam.—

Page 15, Lines 1 and 2, cancel "copending application" and substitute—Patent No. 2,156,519—.

Page 17, Line 1, cancel "upon the diaphragm 17" and substitute—thereupon—.

Claim 29, Line 11, before "alternating" cancel "said"; Line 16, before "means" insert—electrical echo accenting—; Line 18, change "tuning" to read —causing—; same line, before "echoes" insert—periodically recurring—; Line 19, change "selected obstructions" to read

D6

—a series of similar obstructions spaced substantially uniformly along the well—.

Cancel Claims 23, 24, 25 and 30.

Add the following claims:

D7

—31. In a system for receiving and translating

Defendant's Exhibit L—(Continued)

pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon to corresponding impedance variations, means coupling said microphone to said well to expose said microphone to gas pressure in the well, a circuit including a source of alternating current of a frequency many times greater than the frequency of the echoes desired to be translated, said circuit including said microphone so disposed therein as to vary the impedance of said circuit and to therefry or amplitude

by vary ∧ said alternating current in accordance with the pressure variations impinging on said microphone, means coupled to said circuit and responsive to variations of said alternating current in said circuit for describing an observable wave pattern reproduction of the pressure variations in said well, electrical echo accenting means interposed between said microphone and said last named means for causing said system to respond more readily to periodically recurring echoes from a series of similar obstructions spaced substantially uniformly along the well than to pressure variations emanating from other sources, and means associated with said accenting means and operable at will for imposing said accenting means upon said system or for removing the effect of said accenting means from said system.

—32. In a system for receiving and translating pressure echoes from a well, a microphone

Defendant's Exhibit L—(Continued)

adapted to translate pressure variations impinging thereon to corresponding impedance variations, means coupling said microphone to said well to expose said microphone to gas pressure in the well, a circuit including a source of alternating current of a frequency many times greater than the frequency of the echoes desired to be translated, said circuit including said microphone so disposed therein as to vary the alternating current therein in accordance with pressure variations impinging on said microphone, rectifying means coupled to said circuit to produce a direct current, the amplitude of which varies in accordance with the varied alternating current in said circuit, and means coupled to said rectifier and responsive to variations in the amplitude of said direct current for describing an observable wave pattern reproduction of the pressure variations in said well.

—33. In a system for receiving and translating pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon to corresponding impedance variations, means coupling said microphone to said well to expose said microphone to gas pressure in the well, a circuit including a source of alternating current of a frequency many times greater than the frequency of the echoes desired to be translated, said circuit including said microphone so disposed therein as to vary the alternating current therein in accordance with pressure variations impinging on said microphone, means coupled to said circuit and

Defendant's Exhibit L—(Continued)

responsive to variations of said alternating current in said circuit for describing an observable wave pattern reproduction of the pressure variations in said well, and means associated with said circuit for adjusting the natural period of oscillation of said circuit to produce a direct current from said rectifier approximately midway between the normal operating maximum and minimum values when said microphone is subjected only to static pressures.

—34 In a system for receiving and translating pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon to corresponding impedance variations, means coupling said microphone to said well to expose said microphone to gas pressure in the well, a circuit including a source of alternating current of a frequency many times greater than the frequency of the echoes desired to be translated, said microphone being so disposed in said circuit as to vary the normal high frequency of the current imposed on the circuit by said source in accordance with the pressure variations impinging on said microphone, a resonant circuit coupled to receive alternating current from said first circuit and tuned to a fixed frequency which ($\wedge E^1$) ~~is either slightly more than the maximum or slightly less than the minimum frequency~~ caused in said first circuit by said pressure variations, whereby the magnitude of current in said resonant circuit is varied in accordance with said pressure variations, and means coupled to said re-

Defendant's Exhibit L—(Continued)

sonant circuit and responsive to variations in the magnitude of said alternating current for describing an observable wave pattern reproduction of the pressure variations in said well.

—35. In a system for receiving and translating pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon into variations of electric current, means coupling said microphone to said well to expose said microphone to gas pressure in the wall, means responsive to variations of said electric current for describing an observable wave pattern reproduction of the pressure variations in said well, and electric circuit including said microphone and said current responsive electrical tuning means means, and ∧ ~~accenting means~~ interposed in said circuit between said microphone and said current current responsive means responsive means for causing said ~~system~~ ∧ to respond more readily to periodically recurring echoes from a series of similar obstructions spaced substantially uniformly along the well than to echoes from pressure variations emanating from other sources.—

REMARKS

Subsequent to making the amendment of October 17, 1940, this application has been carefully reviewed and it has been found that in a number of places in the specification somewhat inapt language was originally selected for the description of the various devices disclosed and that in order that

Defendant's Exhibit L—(Continued)

the disclosure be accurate and more readily understandable, it is desirable to make changes in the language used as noted in the amendments inserted herewith.

For example, in the Office action of April 22, 1940 it is noted that the Examiner raised several questions with reference to the operation of the systems described and while it was believed that the amendments made in the amendment of October 17, 1940 sufficiently answered these questions, the foregoing amendments made herewith will be of considerable assistance to those who may read this description in the future.

For example, where "wave pattern" is used, it is desirable to point out that this wave pattern is "pressure-time pattern" which is described by either the beam of light on the screen 36 or by the beam of light upon the record tape 35, thus eliminating any possibility of confusion as to the character of the wave pattern referred to.

It is also noted that where in the original specification it was stated that the impulse is "reflected by the various obstructions", it would be more accurate to say that the impulse is "partially reflected by each of the obstructions", which change has been made.

The last few lines of the first paragraph on Page 6 have been corrected to make them read more coherently.

On Page 11 the effect and operation of the condensers 56 employed to vary the sensitivity of the

Defendant's Exhibit L—(Continued)

microphone upon the system has been more fully brought out.

On Page 12 it was noted that there was a reversal of the correct arrangement described and this has been changed to make it accurate.

On page 14 the description has been elaborated to more fully answer the Examiner's question raised in the third paragraph of the last Office action, while at the lower end of Page 14 a paragraph has been inserted to describe more completely the effect of the tuning for the periodically recurring tubing collar echoes.

The Examiner is requested to add the reference character "S" to the switch shown in each of Figs. 2, 4 and 5, as indicated on the accompanying print.

With regard to the claims now remaining in this application, this case has been carefully reviewed and the claims revised so that there is now presented a minimum number of claims to adequately cover the subject matter.

As pointed out in the amendment of October 17, 1940, new Claims 26 and 27 are generic to all of the forms of the circuit shown in Figs. 2, 4 and 5.

Claim 28 is generic to all of the forms of the circuit shown in Figs. 2, 4 and 5 with the additional limitation of the inclusion of the impedances 56 (or 66) in series and in parallel with the microphone to vary the sensitivity of the system.

Claim 29 is generic to all of the circuits and includes as an additional feature the accenting of

Defendant's Exhibit L—(Continued)

such periodically recurring echoes such as echoes of the more or less uniformly spaced tubing collars or casing joints such as by using the tuning apparatus 68-69 associated with any one of the circuits.

Claim 31 is directed to the same subject matter as Claim 29 and includes the feature of tuning the system to accent the tubing collar or other periodically recurring echoes and with the additional limitation of the feature of eliminating this tuning when it is desired to particularly study the unaccented and undistorted wave forms produced as a part of the wave pattern. This is the switch S which is shown shunted about the tuning devices 68 and 69.

New Claim 32 has been substituted for a portion of old Claim 24, this claim being directed now to the generic features of all of the circuits with the additional limitation of employing a rectifier system for translating the current variations in the circuit into variations of amplitude of a direct current which is capable of being passed to the galvanometer and recording apparatus.

Claim 33, which has been substituted for Claim 24, is now presented drawn generically to all of the circuits and including the tuning or adjustment of the system to a mid point between maximum and minimum values when the microphone is subject only to static pressures.

All of Claims 27, 28, 29, 31, 32 and 33 are therefore generic to all of the forms of the invention shown in this application.

Defendant's Exhibit L—(Continued)

Old Claims 21 and 22 have been left in the application as being specific to the circuit arrangement shown in Fig. 2.

New Claim 34 has been inserted specific to Fig. 4.

Old Claim 17 has been left in this application as being specific to Fig. 5.

New Claim 35 inserted herewith has been directed broadly to the features of translating the pressure variations into alternating current variations, which alternating current variations are then translated into a reproduction of the wave pattern but with the accenting of the periodically recurring echoes such as from tubing couplings. This is a geature which is generic to all of the forms of circuit hown and which is clearly patentable over any of the prior art which has been cited in this application.

The total number of claims in this case has been now limited to twelve and each of these claims has been directed to a particular feature of the applicant's system as disclosed, which features are not contemplated in any of the prior art.

It is believed that this amendment will materially assist in advancing the prosecution of this case toward final conclusion and that each of the claims as presented will be found to be allowable.

An early favorable action is respectfully requested

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant

HWM:MM

Encl.

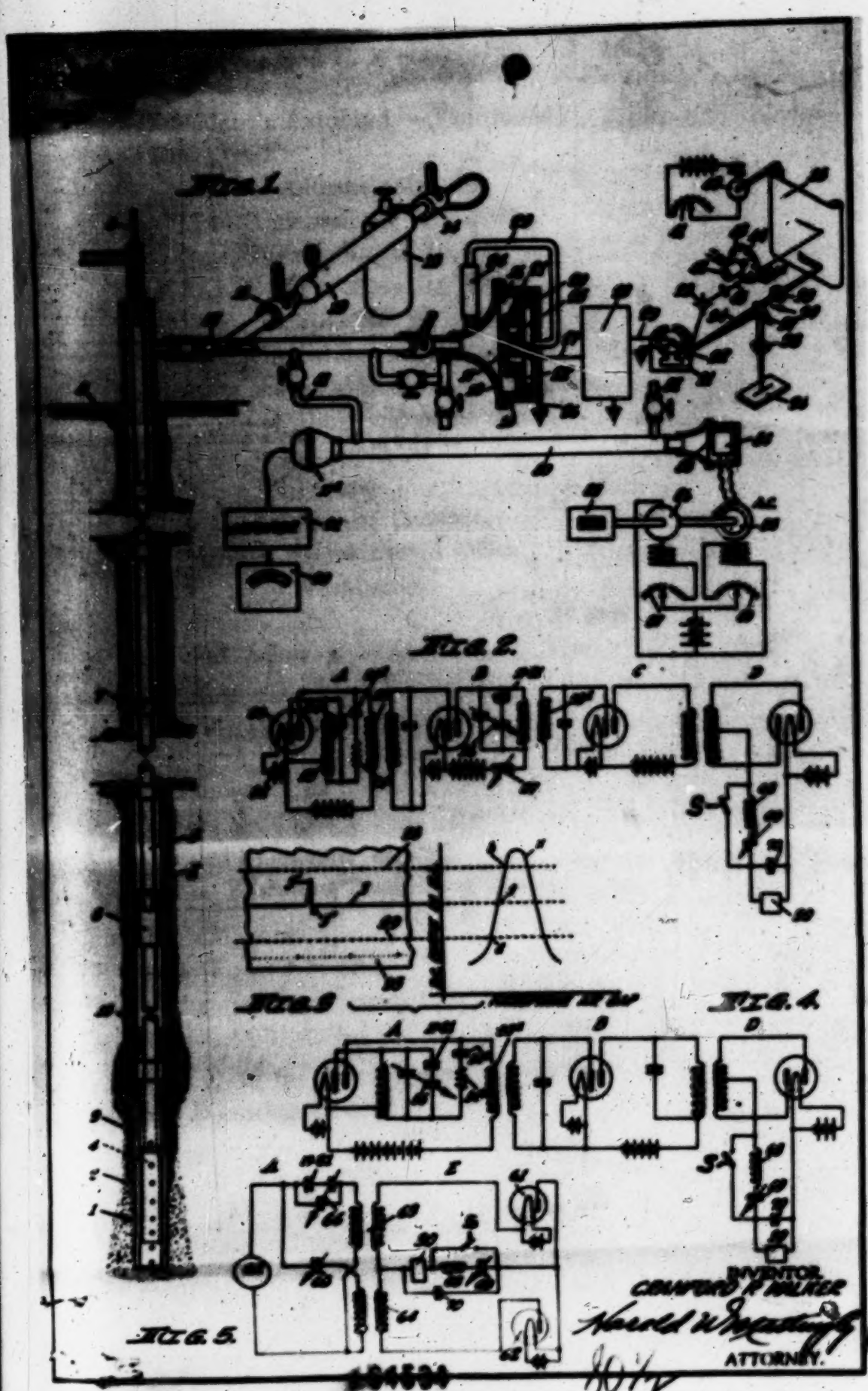


FIG. 1.
FIG. 2.
FIG. 3
FIG. 4.
FIG. 5.
INVENTOR
CRAWFORD R. WALKER
ATTORNEY.

Defendant's Exhibit L—(Continued)

Div. 42 Room 5882

Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name

Paper No. 10

All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

260

Department of Commerce
United States Patent Office
Washington

Mar 29 1941

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE
Commissioner of Patents,

Applicant: Cranford P. Walker
Ser. No. 164,534
Filed September 18, 1937
For Vibration Translating Means

Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope Street,
Los Angeles, California.

Responsive to the amendments filed October 19, 1940, and December 23, 1940:

Defendant's Exhibit L—(Continued)

Added reference:

British 459,723 Lance et al Acc. Jan. 13, 1937 179-171 G(o) (4 pp. spec.; 1 sh. dwg.)

It appears from the British patent cited that it has long been known in the vacuum tube arts that a very low frequency wave could be amplified with great fidelity by modulating a carrier wave with the low frequency wave and rectifying the resultant modulated wave to yield the original low frequency wave. The type of modulation circuit used is apparently immaterial as any type of carrier wave modulator will serve for the purpose.

Upon reconsideration, therefore, claims 17, 21, 22, and 26 through 34 inclusive are rejected on the ground that there would be no invention in applying the idea of carrier wave modulation of low frequencies to the seismic art, in view of the state of the amplifier art as disclosed by British patent 459,723.

The system of Lehr 2,047,974, or any other similar prior art system could without invention be provided with an amplifier of the type described in the British patent (note especially lines 17-27 and 45-53 of page 1 of the provisional specification of the British patent). Espenschied 1,428,156 shows one type of carrier wave modulating circuit used for fidelity of amplification of low frequency waves but any other known type of carrier wave modulator could, without invention, be used instead.

Claim 35 is rejected as defining nothing patentable over Walter 2,156,519. The Walker patent

Defendant's Exhibit L—(Continued)

discloses means for tuning mechanically to the selected echo, but it is obvious that electrical tuning could be used instead in a system comprising an electrical receiving circuit. The two species are not patentably different.

Claim 34 is rejected as alternative in line 14.

H. MARANS,
Acting Examiner.

J.D.S.:dc

Submitted Mar 26 1941. Supervisory Examiner.

Division 42, Paper No Sep 26 1941 U. S. Patent Office.

Mail Division Sep 25 1941 U. S. Patent Office.

In the United States Patent Office
Division 42 — Room 5882
Via Air Mail
Confirmation
Regular Mail

Cranford P. Walker
Vibration Translating Means
Filed September 18, 1937
Serial No. 164,534

Los Angeles, California
September 23, 1941

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In response to the office action of March 29, 1941,

Defendant's Exhibit L—(Continued)

please amend the above identified application as follows:

Claim 34, cancel from "is" in Line 14 through "frequency" in Line 15 and substitute:

E1

—is slightly outside of the range between the maximum and minimum frequencies—.

Claim 35, Line 9, after "and", second occurrence, insert —electrical tuning means—;

Line 10, cancel "accenting means";

Line 12, change "system to read —current responsive means—.

Add the following claim:

E2

—36. In a system for receiving and translating pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon to corresponding impedance variations, means coupling said microphone to said well to expose said microphone to gas pressure in the well, a circuit including a source of alternating current of a frequency many times greater than the frequency of the echoes desired to be translated, said circuit including said microphone so disposed therein as to vary the alternating current therein in accordance with pressure variations impinging on said microphone, rectifying means coupled to said circuit to produce a direct current, the amplitude of which varies in accordance with the varied alternating current in said circuit, means coupled to said rectifier and responsive to variations in the amplitude of

Defendant's Exhibit L—(Continued)

said direct current for describing an observable wave pattern reproduction of the pressure variations in said well, and means interposed between said rectifier and said last named means for accenting the periodically recurring echoes from a series of similar obstructions spaced substantially uniformly along the well over other echoes from pressure variations emanating from other sources.—

REMARKS

Reconsideration of all of the claims in this application is respectfully requested. Insofar as it is possible to understand the last Office action, the Examiner has taken the position that because a British patent shows that it is old and well known to amplify a very low frequency wave by modulating a carrier wave with the low frequency wave and rectifying the resultant modulating wave, then no application of this principle to specific apparatus for performing a specific result can ever thereafter be patentable.

The fallacy of this line of reasoning becomes immediately apparent if the Examiner will consider that this same line of reasoning would prevent the patenting of any combination of pieces of old mechanism put together to perform a specific and new result.

The applicant in devising this system started out on the basis that by measuring the pressure waves emanating from the echoes in a well could be employed to describe or record an observable wave

Defendant's Exhibit L—(Continued)

pattern in which the separate echoes from different types of obstructions in the well could be readily distinguished from each other so as to permit a person studying these wave patterns or records to definitely determine which of the peaks resulted from echoes from tubing joints, which of the echoes resulted from a tubing catcher and which of the echoes resulted from the surface of the liquid in the well.

How to describe or record the desired wave pattern with a maximum of accuracy and fidelity was the problem which was presented to this inventor. After trying many other methods, including the methods described in the Walker patent No. 2,156,519, he devised the arrangements disclosed in the present application as being a satisfactory solution for his problem.

True, this inventor did not invent a system of modulating a high frequency carrier wave and then rectifying the resultant modulated wave nor is he claiming such system broadly.

The inventor does assert and does claim to have invented that combination by which he adapts a low frequency modulation of a high frequency carrier wave and a rectification of the resultant modulated wave and the accenting of certain of the low frequencies either before or after rectification to solve his particular problem of translating the complex but low frequency gas pressure waves resulting from echoes within an oil well into an accurate rec-

Defendant's Exhibit L—(Continued)

ord or chart of the shapes of the wave patterns so as to produce the character of record which upon study and analysis produces the information which is of such great value in accomplishing the objects for which this echo system has substantially supplanted all other methods of obtaining fluid levels, fluid pressures, fluid densities and production capacities of oil wells.

Again it is repeated that the applicant is not claiming that he is the inventor of a modulated carrier wave system but he is claiming and has accurately defined in the claims a combination of apparatus including a modulated carrier wave system by which he can produce with great accuracy and great fidelity a particular desired result.

To deny this applicant protection upon his particular combination by finding a portion of the system claimed in the Lehr patent No. 2,047,974, another portion or a suggestion in this inventor's own earlier patent, and then to have to seek in a third patent (the British patent) other portions of the claimed system is an attempt on the part of the Examiner to build up from these separate sources a teaching which is not contained in any one of them nor is there any teaching in all of these patents how this applicant could solve the problem which confronted him. This line of reasoning on the part of the Examiner is one in which the Examiner, after seeing applicant's disclosure and the way in which applicant has solved his problem, then assumes that because this piece and that piece and

Defendant's Exhibit L—(Continued)

another piece of the apparatus claimed was old that it would not involve invention to take these old pieces and to put them together in the manner which applicant has for the first time disclosed and taught.

The Examiner must admit that the Lehr patent No. 2,047,974 does not teach how to accurately reproduce a wave pattern in which the various echoes from different obstructions can be distinguished from each other in the record which Lehr produced. It is equally obvious that there is nothing in the Lehr disclosure which would teach either the desirability nor how to accomplish the accenting of tubing collar echoes or other periodically recurring echoes. Most certainly there is nothing in the Lehr disclosure which would teach how or where in the system to impose the accenting.

The Examiner must therefore admit that to merely substitute the modulation circuit or modulation system described or hinted at in the British patent No. 459,723 would not accomplish the results which the applicant seeks and which applicant claims and that to adapt such modulation system to applicant's purpose required the applicant to exercise invention of a high order.

Likewise the Examiner must admit that while applicant in his prior patent No. 2,156,519 describes the desirability for accenting the tubing collar echoes and discloses a mechanical arrangement for accomplishing this result, this disclosure would cer-

Defendant's Exhibit L—(Continued)

tainly not defeat applicant's right to obtain claims upon other specific ways of producing this desirable accenting result.

The Examiner also must admit that this applicant is clearly entitled to a protection upon other specific arrangements for producing this accenting electrically in an electrical translation system as distinguished from a mechanical translation system.

Applicant admits that the broad idea of electrical tuning for tubing collar echoes is the full mechanical equivalent of the mechanical means which applicant disclosed in his earlier patent.

Where the Examiner falls into error is that applicant is not in his claims attempting to cover the broad idea of electrical accenting but instead he is seeking protection upon a specific arrangement and a specific location of his electrical accenting mechanism.

It is therefore respectfully requested that the Examiner reconsider each of the claims of this application and to carefully analyse each of these claims. Applicant is confident that upon making such careful analysis the Examiner will find that each of the claims presented in this application is directed to, not merely the broad idea of translating gas pressure waves in the well into a record of the pressure waves, not merely the broad idea of imposing electrical tuning or accenting for bringing out the registration of selected recurring echoes, but instead a particular arrangement of circuits

Defendant's Exhibit L—(Continued)

and tuning means by which he accomplishes that result.

Claim 34 has been amended to correct the objectionable feature pointed out by the Examiner while Claim 35 has been amended to more clearly distinguish applicant's electrical accenting mechanism from the mere mechanical equivalent or broadly electrically accenting or tuning instead of mechanical accenting or tuning, as was disclosed in applicant's earlier patent.

New Claim 36 is presented to cover the particular location of applicant's tuning and filtering devices such as 68, 69, 70 as being interposed between the rectifier and the wave pattern describing device such as 31 to set forth even more specifically that form of tuning or accenting for the periodically recurring echoes.

It is believed that upon making the reconsideration and analysis requested herein the Examiner will withdraw the character of rejection entered in the last Office action and will find each of the claims presented to be allowable. If upon this reconsideration the Examiner feels that such rejection should stand, he is respectfully requested to make such rejection final so that an immediate appeal may be taken.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant.

HWM:MM

Defendant's Exhibit L—(Continued)

Div. 42—Room 5882.

260

DEPARTMENT OF COMMERCE

United States Patent Office
Washington
Address only
"The Commissioner of Patents
Washington, D. C."
and not any official by name
Paper No. 12
All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Jan 14 1942

Please find below a communication from the EXAMINER in charge of this application.

CONWAY P. COE
Commissioner of Patents.

Applicant: Cranford P. Walker
Ser. No. 164,534
Filed September 18, 1937
For Vibration Translating Means

Harold W. Mattingly,
924 Pacific Finance Building,
621 S. Hope Street,
Los Angeles, California.

Responsive to the amendment filed September 25, 1941:

Defendant's Exhibit L—(Continued)

Of interest:

1,780,567 Rieber Nov. 4, 1930 177-352.7x

Claims 17, 21, 22, 26 through 34 and 36 appear to be allowable.

The rejection of claim 35 as defining nothing patentable over prior art systems is repeated. Since applicant is not the first to utilize an electrical receiving circuit to receive well echoes, the examiner is still of the opinion that in view of Walker 2,156,519 there would be no invention in using tuning means in the electrical circuit between the echo receiving means and the recording means. Applicant's argument with regard to the specific location of the accenting mechanism has been considered. The normal method of electrically accenting one of a plurality of received frequencies is by a tuned circuit such as applicant uses. It is old to do the tuning at the recording point; this is shown, for example, in Rieber in which seismic echoes are received by the use of a carrier wave to derive an observable wave pattern reproduction of the echoes, and an echo of a desired frequency is accented in the receiving circuit after the carrier wave has been rectified.

The foregoing action closes the prosecution of the case before the Examiner. Any amendment of request for reconsideration which on inspection is found to require reexamination of the case will not be entered, but, if promptly filed, may be given consideration a reasonable time prior to the expira-

Defendant's Exhibit L—(Continued)

tion of the statutory period. (See ex parte Peterson, 1928 C. D. 31.)

This rejection is made FINAL.

H. P. CUTTING
Examiner.

JDS.
JDS:dc

1937

CONTENTS

1. Application .....papers.
2. Print Sept. 23/37
3. Rejection Jan 17 1938
4. Amdt. A July 15, 1938
5. Rejection Apr 5 1939
6. Amdt. B Oct. 2, 1939.
7. Rejection Apr 22 1940
8. Amdt C Oct. 19, 1940
9. Amdt. D Dec. 23, 1940
10. Rejection Mar 29 1941
11. Amdt. E Sept. 25, 1941.
12. Final Rejection Jan 14 1942

Defendant's Exhibit L—(Continued)
In the United States Patent Office
Div. 42

In re application of:

CRANFORD P. WALKER

Ser. No. 164,534
Filed September 18, 1937

VIBRATION TRANSLATING MEANS

* * * * * * *

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

REQUEST FOR FURTHER EXPLANATION

Applicant notes the entry of the Office action of January 14, 1942 in which claim 35 was rejected as defining nothing patentable over the prior art systems, particularly over the Walker patent 2,156,519 apparently on the ground that the electrical tuning defined in claim 35 is the mechanical equivalent of the mechanical tuning shown in the earlier Walker patent.

However, the Rieber patent referred by the Examiner does not disclose electrical tuning nor does it indicate that electrical tuning is the mechanical equivalent of Walker's earlier mechanical arrangement, since the Rieber patent shows the tuning as being accomplished by the mechanical tightening or loosening of the "string" on his string galvanometer.

Defendant's Exhibit L—(Continued)

Under these circumstances it is believed that the rejection of claim 35 should be withdrawn unless the Examiner can find a reference patent which demonstrates that the mechanical tuning and electrical tuning are considered as interchangeable and as the mechanical equivalent of each other.

It is requested therefore that before closing the prosecution of this case the Examiner reconsider the rejection of claim 35 for the reasons indicated above.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant.

Washington, D. C.,
April 6, 1942.

(Copy)

Div. 42, Room 308 Paper No. 14

DEPARTMENT OF COMMERCE

Richmond, Va.

Applicant: Cranford P. Walker
Serial No. 164,534
Filed Sept. 18, 1937
For Vibration Translating Means.
Mailed April 11, 1942

Harold W. Mattingly
621 South Hope Street
Los Angeles, California

Responsive to the letter of April 6, 1942.

Defendant's Exhibit L—(Continued)

Attention is directed to

1,498,238 Holland June 17, 1924 177-314x

The equivalence of electrical tuning and mechanical tuning for selective reception was thought to be so generally recognized that citation of an illustrative reference was not considered necessary. In view of applicant's request for further explanation, however, the Holland patent is referred to as one illustration of the interchangeability of mechanical and electrical tuning for selection purposes. Fig. 2 shows the use of mechanical tuning means while Fig. 3 shows the use of electrical tuning means for the selective operation of the signal S through relay winding 18.

This application stands under the final rejection of Jan. 14, 1942.

Examiner.

Defendant's Exhibit L—(Continued)
(Copy)

In the United States Patent Office
Division 42—Room 308

CRANFORD P. WALKER
VIBRATION TRANSLATING MEANS

Filed September 18, 1937
Serial No. 164,534

Los Angeles, California
July 7, 1942

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In response to the Office actions of April 11, 1942 and January 14, 1942, please amend the above identified application as follows:

Cancel Claim 35.

Claim 36, next to the last line, cancel "other echoes from".

In preparing the application for issue, please renumber the claims as follows:

Claim	26	to	become	Claim	1
"	27	"	"	"	2
"	28	"	"	"	3
"	29	"	"	"	4
"	31	"	"	"	5
"	32	"	"	"	6
"	33	"	"	"	7
"	21	"	"	"	8
"	22	"	"	"	9
"	34	"	"	"	10
"	17	"	"	"	11
"	36	"	"	"	12

Defendant's Exhibit L—(Continued)

REMARKS

The foregoing amendment to Claim 36 has been made since upon reading this claim it is found that the last two lines of this claim included a redundancy which made the claim inaccurate. The claim should recite the accenting of the periodically recurring echoes over pressure variations emanating from other sources and the words "other echoes from" are not only unnecessary but are a double inclusion of echoes and the pressure variations resulting from such echoes.

Upon reviewing the claims it is believed that the claims will appear in better order in the issued patent if renumbered and arranged as requested above.

The cancellation of Claim 35 places this case in condition for immediate allowance, which action is respectfully requested.

Respectfully submitted,

HAROLD W. MATTINGLY
Attorney for Applicant

HWM:MM

(Copy)

Div. 42 Paper No. 16

Department of Commerce
Richmond, Va.

Applicant: Cranford P. Walker
Ser. No. 164,534
Filed Sept. 18, 1937
For Vibration Translating Means
Mailed July 22, 1942

Defendant's Exhibit L—(Continued)

Harold W. Mattingly
621 S. Hope Street
Los Angeles, California

In accordance with the provisions of Order No. 2308, dated March 12, 1917, which reads in part as follows:

> Obvious informalities in the application may be corrected by the Examiner, but said correction must be in the form of an amendment, approved by the Principal Examiner in writing, placed in the file, and made a part of the record. The changes specified in the amendment will be entered by the clerk in the regular way.

the changes, hereinafter specified, are made by the examiner in the application above identified.

Should these changes not be satisfactory to the applicant, appropriate amendment may be proposed under the provisions of Rule 78, provided the specification has not been printed.

The application has been amended as follows:

Page 11, line 2, after "will' insert —cause it to—.

Page 13, line 12, insert —and— before "is".

Renumbered claim 11, line 3, singularize "impedances".

Examiner.

[Endorsed]: Filed Nov. 10, 1942.

O-2

DEFENDANT'S EXHIBIT O-2

Patent No. 602,422 Dated: Apr. 19, 1898

To

B. C. BATCHELLER

For

APPARATUS FOR LOCATING OBSTRUCTIONS IN TUBES

[Endorsed]: Filed Nov. 4, 1942.

1066

(No Model.)

2 Sheets—Sheet 2.

B. C. BATCHELLER.

APPARATUS FOR LOCATING OBSTRUCTIONS IN TUBES.

No. 602,422. Patented Apr. 19, 1898.

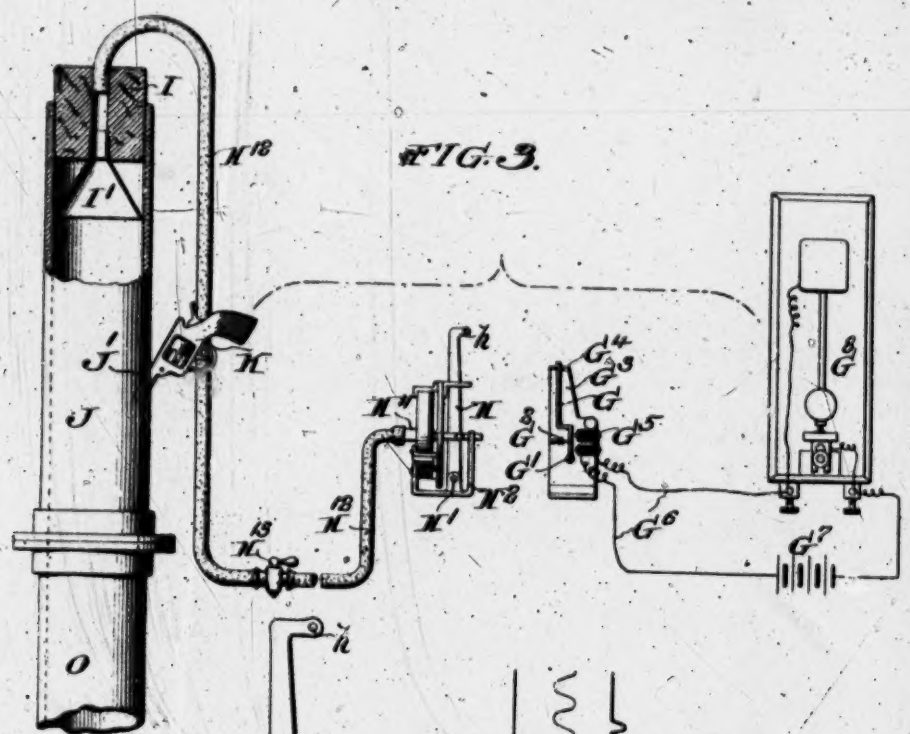


FIG. 3.

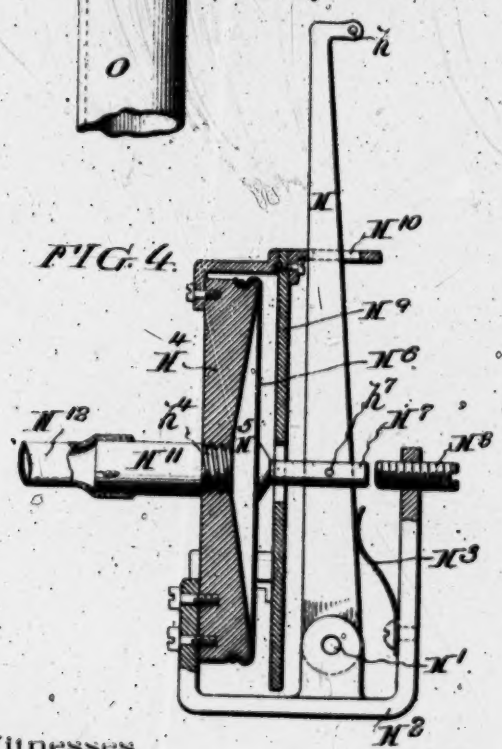


FIG. 4.

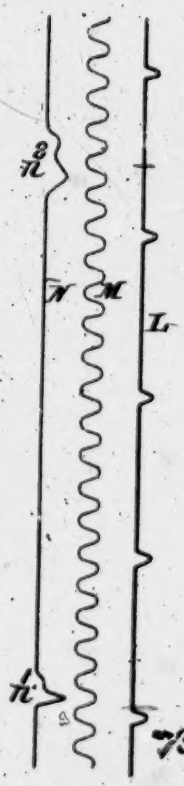


FIG. 5.

Witnesses.

Henry Drury

D. Stewart

Inventor.

Birney C. Batcheller

by Francis T. Chambers

his Attorney.

1068

(No Model.)

2 Sheets—Sheet 1.

B. C. BATCHELLER.

APPARATUS FOR LOCATING OBSTRUCTIONS IN TUBES.

No. 602,422. Patented Apr. 19, 1898.

FIG. 1.

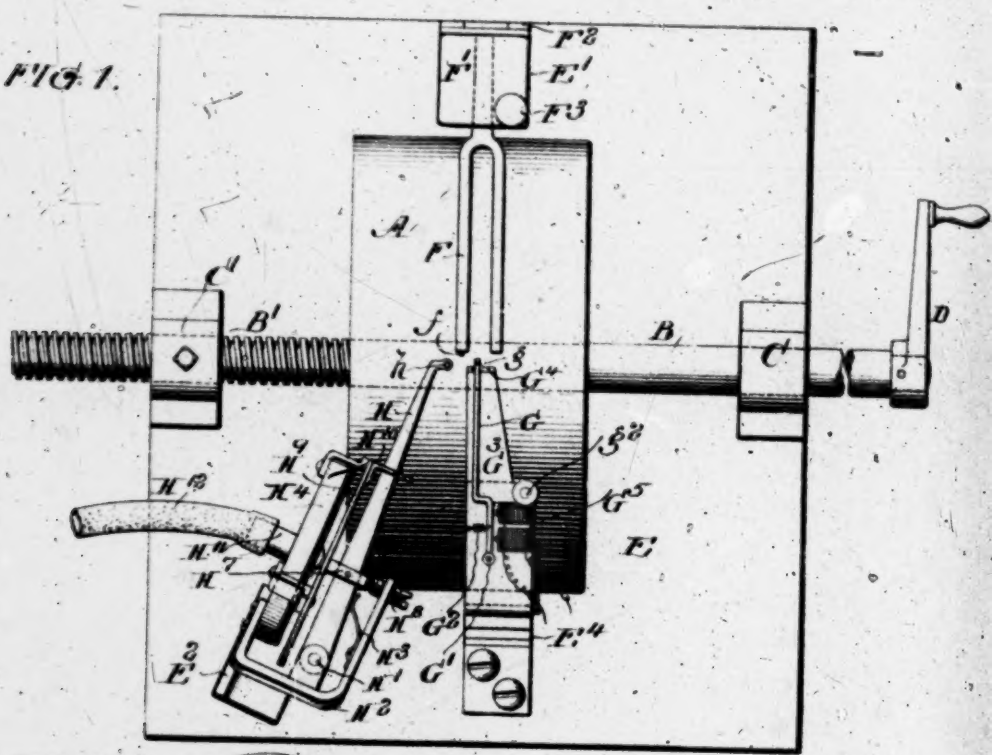
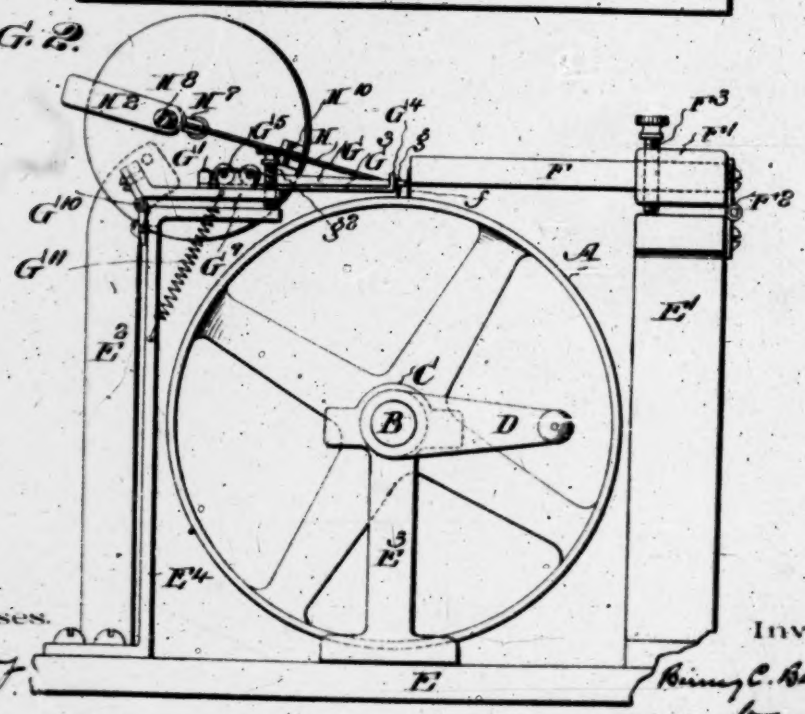


FIG. 2.



Witnesses.

Henry Drury

D. Stewart

Inventor.

Birney C. Batcheller

by

Francis T. Chambers

his Attorney.

UNITED STATES PATENT OFFICE.

BIRNEY C. BATCHELLER, OF PHILADELPHIA, PENNSYLVANIA.

APPARATUS FOR LOCATING OBSTRUCTIONS IN TUBES.

SPECIFICATION forming part of Letters Patent No. 602,422, dated April 19, 1898.

Application filed September 28, 1897. Serial No. 653,340. (No model.)

To all whom it may concern:

Be it known that I, BIRNEY C. BATCHELLER, a citizen of the United States of America, residing in the city and county of Philadelphia, in the State of Pennsylvania, have invented a certain new and useful Improvement in Methods of and Apparatus for Locating Obstructions in Tubes, of which the following is a true and exact description, reference being had to the accompanying drawings, which form a part thereof.

My invention relates to a new method for locating obstructions in pneumatic or other tube systems and to improved mechanism especially adapted for carrying my mechanism into practical use.

It has heretofore been attempted with varying degrees of success to locate obstructions in long tubes by ascertaining and recording the lapse of time intervening between the creation of a sound impulse in the tube at a certain point and the reflection or echo of the said sound returning to the said point after being reflected from the obstruction in the tube. The velocity of the sound-wave being a known factor, it is easy to compute from the data thus obtained the distance of the obstruction from the point in the tube at which the test is made.

My invention is an improvement upon the method briefly described above; and in its main feature it consists in wholly or partly closing the connection from the tube to be tested to the sound and time recording apparatus at the time when the sound impulse is created in the tube and then fully and freely opening the said connection before the echo or reflection of the said sound returns to the point in the tube where the test is made, my purpose being to avoid an undue and disruptive shock to the recording apparatus, such as would be apt to occur if the recording apparatus was in full connection with the tube at the time the sound is made and at the same time to cause the weaker reflected sound to act directly and with full force upon the recording apparatus.

In carrying my invention into effect I have devised a connection between the tube and the recording apparatus of such a character or provided with such appliances that it may be partially or wholly closed when the impulse is created and freely and entirely open before the return of the echo or reflected sound-wave. Another useful and valuable feature of my invention consists in protecting the diaphragm, to which the sound-waves are communicated and through which they are transmitted to the recording mechanism, against undue and disruptive shock by placing in front of it a shield or protecting-plate, against which it is impelled in the event of its being exposed to a dangerous sound impulse and by means of which its outward movement to a disruptive point is prevented.

The nature of my improvements will be best understood as described in connection with the drawings, in which it is illustrated, and in which—

Figure 1 is a plan view of the recording apparatus; Fig. 2, a side elevation of the same; Fig. 3, a diagrammatic illustration of the various appliances making up the recording apparatus and connected therewith and all of the means for connecting the recording apparatus with the tube and for creating a sound impulse in the tube. Fig. 4 is an enlarged sectional view of the sound-recording diaphragm and its immediate connections, and Fig. 5 a diagrammatic illustration of the record made by the appliances shown when in operation.

A is a cylinder having a smooth surface, which in use is coated with lampblack or some other film upon which a light stylus will make a visible impression. This cylinder is secured to a shaft B, threaded at one end, as indicated at B', and resting in convenient bearings, as indicated at C and C', bearing C being threaded to engage the threaded portion of the shaft B.

D is a crank by which the shaft and cylinder can be turned, and obviously as they turn they are by the action of the screw B' longitudinally and gradually moved. While I have indicated a crank as a convenient device for rotating and moving the cylinder, it will of course be understood that any convenient driving apparatus may be substituted therefor. As shown, the cylinder is mounted on a base E, the bearings C and C' being supported on standards E^3, extending up from the side piece, and other standards, as indicated at E', E^2, and E^4, being provided

as supports for the appliances hereinafter described.

F is a tuning-fork of known pitch, having a light stylus (indicated at *f*) attached to one of its prongs in position to rest lightly on the cylinder A. The tuning-fork, as shown, is attached to a block F', hinged to the standard E' at F², an adjusting-screw F³ serving to adjust the pressure with which the stylus *f* will rest against the cylinder A. In practice I may state I have used a tuning-fork giving the note "C" of the musical scale and having a known rate of five hundred and twelve single vibrations per second. The wave-line produced by the stylus produced by the said tuning-fork is diagrammatically illustrated at M in Fig. 5, each single vibration thus recorded measuring one five hundred and twelfth ($\frac{1}{512}$) of a second.

G is a light rod pivotally supported on a block G', hinged at G¹⁰ to the standard E' and adjustable in height by means of the adjusting-screws *g*². An extension G², having a turned-up and slotted end G⁴, serves to support the outer end of the light lever or rod G, to which is attached the stylus *g*, the said rod or lever being pivoted at G' to the block G'. A spring G², acting on the lever G, draws it away from an electromagnet, (indicated at G⁵,) said electromagnet when energized overcoming the tension of the spring and drawing the lever G toward it. The energizing of the magnet is conveniently effected at definite time intervals, as indicated in Fig. 3, G⁶ indicating circuit-wires in which is situated a battery G⁷ and a pendulum or equivalent escapement (indicated at G⁸) and by means of which the circuit is closed at definite time intervals. For instance, I have found it convenient to use a pendulum of such length that the circuit will be closed once in each half-second, and the record upon the cylinder A effected by the stylus *g* will be of a character indicated at L in Fig. 5, such a record serving in connection with the tuning-fork record M to greatly facilitate the computation of the total time interval.

The sound-impulse-recording mechanism operates a light pivot-lever H, having at its end a stylus *h*. This lever, as shown, is pivoted to a frame H², supported on the standard E², the pivot being indicated at H', a light spring H³ acting to press the lever H in one direction, as shown in Figs. 1 and 4, and an adjusting-screw H⁸ being provided as an abutment to prevent the movement of the lever H against the spring beyond a definite point. The lever is actuated by a connection H', connected also to a diaphragm H⁶, which is secured to a block H⁴, hollowed out to form a chamber H⁵, into which opens a passage *h*⁴, or rather a tubular connection H¹¹, screwing into the passage *h*⁴. The tubular connection H¹¹ is in turn connected with the tube to be tested conveniently, as shown, by a flexible pipe H¹², opening through a block I, having a funnel-shaped internal opening I', into a pipe-section J, which, as shown, is connected with the tube O to be tested and is formed with an opening J', through which a pistol-barrel can be inserted, K, Fig. 3, indicating the pistol in position to be fired.

It will be understood that an important feature of my method and also of my apparatus is the provision of means whereby the tubular connection between the tube to be tested and the sound-recording apparatus can be partly closed. Any convenient device may be employed for this purpose and among them a cock A¹³, Fig. 3, which is a ready and simple means of partly closing and quickly opening the flexible tube H¹².

In order to further protect the diaphragm H⁶ against disruptive sound-waves, I employ a shield or protecting-plate H⁹, placed in front of it at a distance which will permit of its normal vibration, but which in case of an impulse adapted to have a disruptive effect upon the diaphragm will arrest the motion of the diaphragm and prevent its being forced out beyond a safe limit.

The character of the record made by the stylus *h* is indicated at N in Fig. 5, *n*' indicating the record made at the time the pistol is fired and *n*² the record made on the return of the echoes or reflected wave.

The operation of my device will be readily understood from what has already been said. When a test is to be made, the time-recording apparatus is set in operation, as is also the cylinder A, with the effect of making a record, such as M, or preferably such as M and L. The operator then partially closes the cock H¹³ and fires the pistol K into the pipe-section J, as a result of which a sound-wave is transmitted through the partially-closed connection to the diaphragm H⁶ and by it through the mechanism described to the stylus *h*, which makes a record, as indicated at *n*'. The operator then fully opens the cock H¹³, and upon the return of the echo or reflected sound, which is of course much weaker than the initial sound, its impulse passes freely through the connection to the sound-recording apparatus, the stylus *h* making a record of the return of the sound, as indicated at *n*². The work of calculating the distance of the obstruction against which the sound has been reflected is then simply the coördinated records enabling the operator to ascertain within a very short distance the exact position of the obstruction.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The method of locating obstructions in tubes which consists in connecting the tube to be tested with an apparatus for recording time-intervals and sound-waves created in the tube, making a loud noise, as by an explosion, in the part of the tube to which the recording apparatus is attached partly closing the connection from the tube to the recording apparatus prior to the making of said loud noise

so as to avoid an undue strain on the
ng apparatus and immediately open-
d connection after the sound impulse
ted in the tube so as to afford a free
e to the recording apparatus for the
impulse reflected from the obstruction
tube.

n an apparatus for locating obstruc-
n tubes—the combination with an ap-
s for visually recording time intervals
ans for coördinately recording sound-
said means being connected with the
o be tested as described and so that
-waves created in said tube will be visu-
ecorded, and means for wholly or par-
interrupting the transmission of the
-waves from the tube to the sound-re-
g device.

In an apparatus for locating obstruc-
in tubes consisting of a device for visu-
ecording time intervals and means for
inately recording sound impulses cre-
in the tube to be tested, the combination
ubular connection leading from the tube to be tested, a diaphragm open to sound impulses coming through said connection, a stylus actuated by said diaphragm to record the sound impulses and means for varying the opening through the tubular connection to the diaphragm.

4. In an apparatus for locating obstructions in tubes consisting of a device for visually recording time intervals and means for coördinately recording sound impulses created in the tube to be tested, the combination of a tubular connection leading from the tube to be tested, a diaphragm open to sound impulses coming through said connection, a stylus actuated by said diaphragm to record the sound impulses and a guard-plate situated in front of the diaphragm arranged to check its outward movement beyond a point of safety.

BIRNEY C. BATCHELLER.

Witnesses:
CHAS. F. MYERS,
D. STEWART.

DEFENDANT'S EXHIBIT O-4

Fessenden Patent No. 1,240,328

[Endorsed]: Filed Nov. 4, 1942.

R. A. FESSENDEN.

METHOD AND APPARATUS FOR LOCATING ORE BODIES.

APPLICATION FILED JAN. 15, 1917.

1,240,328.

Patented Sept. 18, 1917.

Fig. 1.

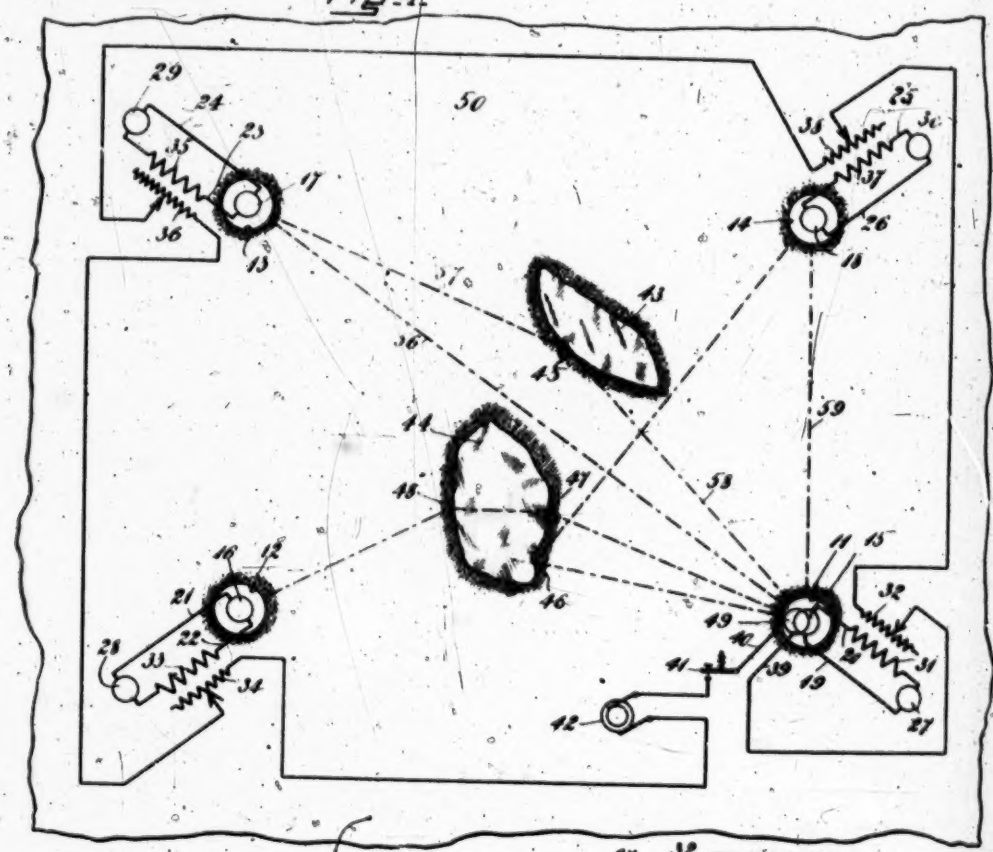


Fig. 2.

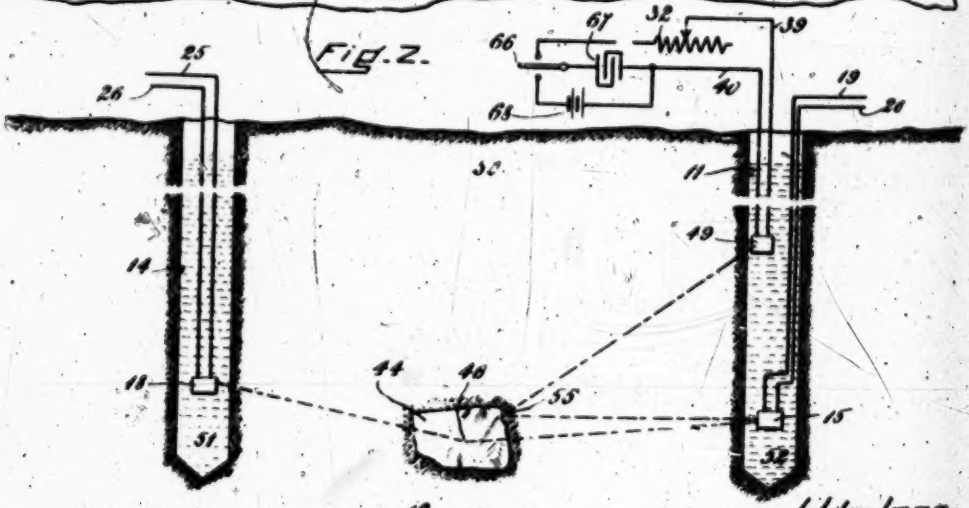


Fig. 3.

INVENTOR:
Reginald A. Fessenden
By Cotton & Hayes
HIS ATTORNEYS.

UNITED STATES PATENT OFFICE.

REGINALD A. FESSENDEN, OF BROOKLINE, MASSACHUSETTS, ASSIGNOR TO SUBMARINE SIGNAL COMPANY, OF WATERVILLE, MAINE, A CORPORATION OF MAINE.

METHOD AND APPARATUS FOR LOCATING ORE-BODIES.

1,240,328. Specification of Letters Patent. Patented Sept. 18, 1917.

Original application filed April 2, 1914, Serial No. 828,972. Divided and this application filed January 15, 1917. Serial No. 142,421.

To all whom it may concern:

Be it known that I, REGINALD A. FESSENDEN, of Brookline, in the county of Norfolk and State of Massachusetts, a citizen of the United States, have invented a new and useful Improvement in Methods and Apparatus for Locating Ore-Bodies; of which the following is a specification.

This application is a division of my United States application Serial No. 828,972 filed April 2, 1914.

The invention described herein relates to methods and apparatus whereby, being given or having ascertained, two or more of the following quantities, *i. e.*, time, distance, intensity and medium, one or more of the remaining quantities may be determined.

For example, being given the distance between two points in a mine, and having determined the time taken by a sound wave to travel between the two points, it is possible to draw conclusions in regard to the probable nature of the rock between the two points, or if an echo be observed, or a refraction of the sound, it is possible to estimate the distance of the reflecting or refracting vein.

Heretofore only such ore bodies have been discovered as have had an edge of the mineral vein extending to the surface of the earth and not covered by debris to such an extent as to be hidden, or such as have been reached by drill holes sunk at random in locations where minerals were suspected. The ore bodies so discovered must form an extremely small fraction of the total of such bodies and it is the object of the present invention to disclose methods and apparatus for discovering such hidden ore bodies by means of measurements made on the velocity, direction, reflection, refraction, absorption and other phenomena, of sounds transmitted through the medium containing the ore bodies, *i. e.*, the earth.

By the method herein described I have been able to detect and determine the location of a body of mineral, invisible to the eye, at a distance of two and a half miles, and farther, the test being witnessed and verified by a number of skilled engineers.

In the drawings accompanying and forming a part of this specification,

Figure 1 is a diagrammatic plan, and

Fig. 2 an illustrative section showing also a different source of energy.

Fig. 3 is a modification of the receiver, these views being in part diagrammatical and showing apparatus and methods suitable for carrying out my invention.

In Figs. 1 and 2, 50 represents a territory, which may be assumed to have an area of 25 square miles, within which it is desired to determine the presence or absence of mineral veins.

Four drill holes, 11, 12, 13, 14, shown in plan in Fig. 1 and two of them in section in Fig. 2, are first drilled at the four corners of the territory, approximately five miles apart, and of a depth sufficient to secure the desired results. These holes are filled with water 51, 52, Fig. 2. Sound detective devices, 15, 16, 17, 18, such as microphones or preferably small oscillators, as described in United States Patent No. 1,167,366, January 4, 1916, are suspended in these holes below the water line.

These sound receiving devices are connected by the pairs of leads, 19, 20, 21, 22, 23, 24, 25, 26, to the secondaries 31, 33, 35, 37, of transformers, as shown, and to oscillographs of the usual photographic recording type, but preferably with the galvanometer elements of the quartz fiber, described by applicant at the American Association for the Advancement of Science, 1894, and commonly known as Einthoven galvanometers.

49 is a sound producing apparatus, preferably of the said oscillator type, connected by its leads, 39, 40, to the primaries 32, 34, 36, 38, of the transformers in the oscillograph circuits, and to the alternating current dynamo 42, when the key 41 is depressed. 43, 44 are ore bodies.

The primaries 32, 34, 36 and 38 of the transformers are adjustable with reference to the secondaries, as shown, and are so adjusted that when the key 41 is depressed a moderately strong indication is produced on the photographic records of the oscillographs 27, 28, 29, 30, which fixes on the photographic records the instant at which the key is depressed, and at the same time a sound is sent out from the oscillator 49, which after being reflected as at 45 by the ore body 43, or reflected back as from 55, Fig. 2, by the ore body 44, or reflected as from 46 by the ore body 44, or refracted as at 47, 48 by the ore body 44, or proceeding directly through the earth, as shown by the dotted lines 56, 57, reaches the indicators 17, 18, 16,

15, and is recorded on the oscillographs 29, 30, 28, 27.

Since the oscillograph photographic strip moves with a regular and known velocity, determined in the manner well known in the art, the distance on the strips between the records produced through the transformers when the key 41 was pressed down, and the records made by the sounds received whether direct, or by reflection or refraction or by the echo, will indicate the distance between the drill holes and the ore bodies.

For example, if the distance between the record made on the oscillograph 30 by the transformer 37, 38 on depressing the key 41, and the record made by the arrival of the sound directly along the line 59 (which would be easily identified, being the first sound to record itself after the depression of the key), is five inches, then one inch on the record corresponds to one mile in distance, since 11 is five miles from 14. This establishes the standard of measurement on the oscillograph.

If, then, the length between the key depression record and the record made at 30 by the sound reflected at 46 is 9 inches, it is evident that the sound proceeding out from 49 and reflected at 46 and finally reaching 14, has traveled 9 miles. If, again, the length between the key depression record on the oscillograph 27 and the record made by the sound sent out from 49 and reflected back from 55, Fig. 2, is eight inches, then it follows that the ore body 44 is approximately 4 miles from the point 11. The ore body therefore lies at the intersection of the sphere described about 49 with radius 4 miles, with the sphere described about 18 with radius 9 minus 4, *i. e.*, 5 miles.

The exact point on the line of intersection may be found in a number of ways. For example:

1. By placing 49 in the drill holes 12 or 13 or 14 and taking other sets of records another line of intersections may be found. The point of intersection of the two lines of intersection will give the point at which the ore body is, or sufficiently close thereto.

2. By determining, by means of the apparatus of applicant's United States application Serial No. 54,556, filed October 7, 1915, shown diagrammatically in Fig. 3, and referred to below, the exact direction of the reflection points 46 of Fig. 1 and 55 of Fig. 2, thus knowing the directions and the distances obtained as given above, the ore body is located.

3. By drilling a test hole, passing near but on the far side of the line of intersection obtained as above,

Other modifications of applicant's method may be used. In fact, the mere determination of the time elapsing between the key depression record and the echo record made by reflection at 55, Fig. 2, together with a determination of the direction from which the echo is received is sufficient.

The extent of the ore body can be obtained by readings made by transferring 49 to the drill holes 12, 13, 14, and taking readings on the oscillographs on sending out sounds at these drill holes; or it may be determined by the refraction of the sound sent out from 49 and received at 16, or by the echo obtained at 16 when the sounder 49 is operated at the drill hole 12.

In place of using an alternator 42, a condenser discharge may be used to actuate the sounder 49, as shown in Fig. 2. Here the condenser key 66, on being depressed, charges the condenser 67 from the battery 68 and on the key being released and coming up against the top key contact, discharges the condenser through the transformer secondary 32 and sounder 49, thus making a single sound impulse, or a rapidly oscillating one, if the discharge is an oscillatory one.

The vertical angle of reflection may be determined by hauling the transmitter 49 or the receivers 18, 15, up or down in the drill holes.

In Fig. 3 is shown the apparatus for determining the direction of the sound received. Here 15, 15′, are two sound receivers, preferably small oscillators, connected in series preferably, their leads being the conductors 19, 20, connected to the oscillograph 27,

53 is a rod supporting the two receivers, 15, 15′, by which they may be turned in any direction. On turning them, the sound will be a maximum if they are connected so as to assist each other, when they are in a plane at right angles to the direction of the received sound. If they are connected so as to oppose each other, the sound will be a minimum when they are in this plane. In this way by drawing a perpendicular to the plane so determined, the direction from which the sound comes may be determined.

By the term "sound inflection" I mean bending of the line of sound propagation, either by reflection, or by refraction.

What I claim is:

1. That method of determining the location of ore bodies which consists in generating sound waves and observing their inflection.

2. That method of determining the location of ore bodies by generating sounds and observing their inflection by the ore bodies, and their velocities.

REGINALD A. FESSENDEN.

DEFENDANT'S EXHIBIT 0-5

Tucker Patent No. 1,351,356

[Endorsed]: Filed Nov. 4, 1942.

1078

W. S. TUCKER.

SOUND DETECTING DEVICE.

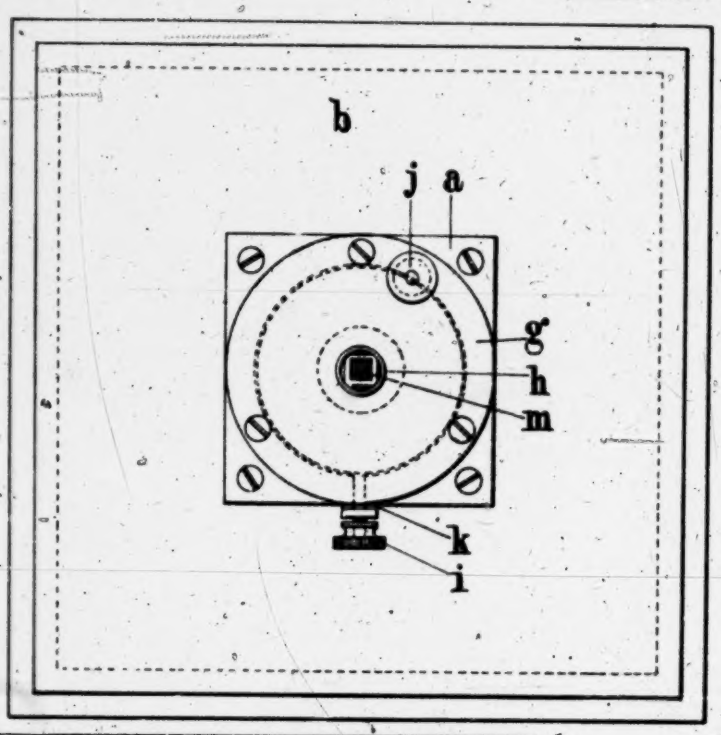
APPLICATION FILED JAN. 9, 1919.

1,351,356.

Patented Aug. 31, 1920.

4 SHEETS—SHEET 1.

Fig.1.



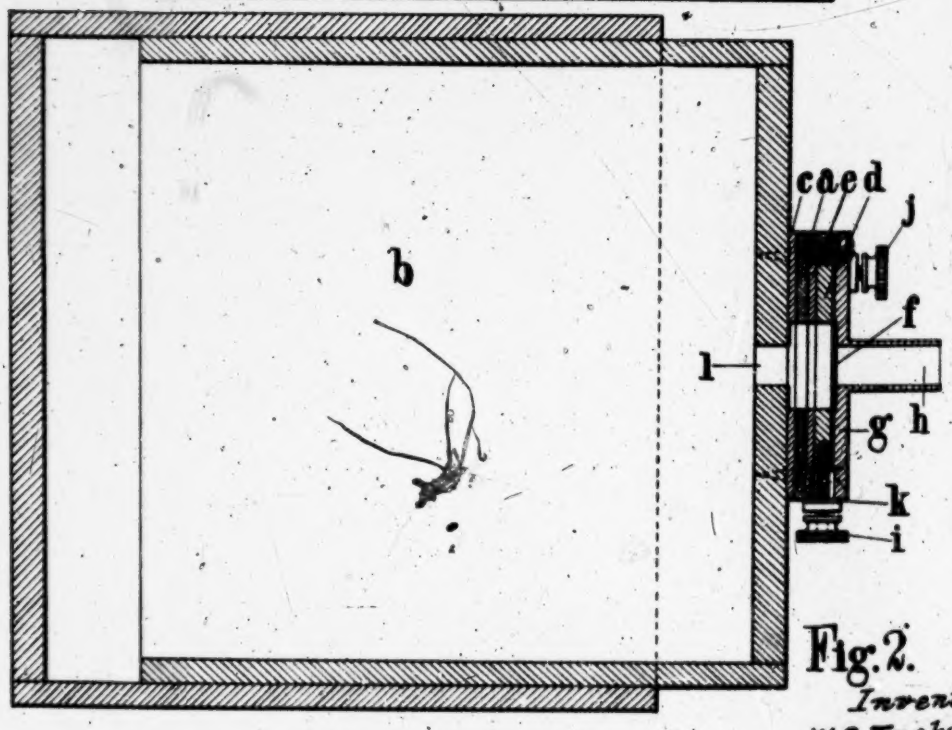


Fig.2.

Inventor
W.S. Tucker
By A.R. Kerslake
Atty

1075

W. S. TUCKER.
SOUND DETECTING DEVICE.
APPLICATION FILED JAN. 6, 1919.

1,351,356.

Patented Aug. 31, 1920.
4 SHEETS—SHEET 2.

Fig.3.

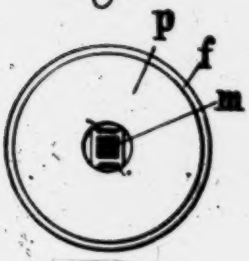


Fig.4.

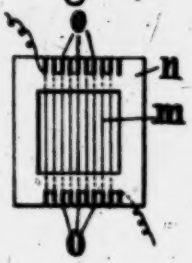
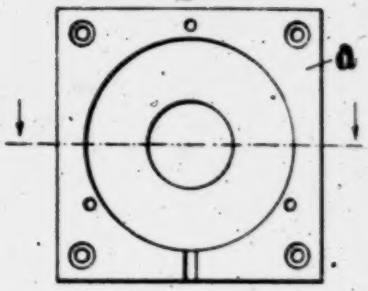


Fig.7.



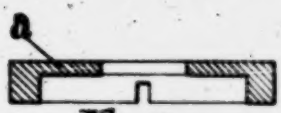


Fig.8.

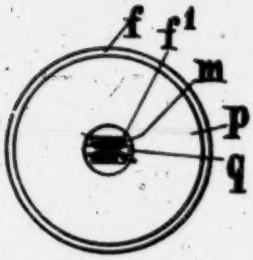


Fig.5.

Fig.6.

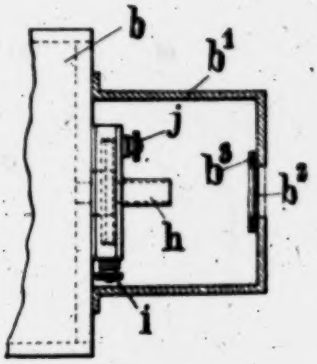


Fig.11.

Fig.9.

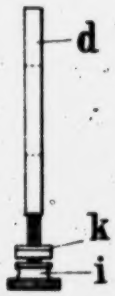


Fig.10.

Inventor
W. S. Tucker
By H. R. Kerslake
Atty

1080

W. S. TUCKER.

SOUND DETECTING DEVICE.

APPLICATION FILED JAN. 6, 1919.

1,351,356.

Patented Aug. 31, 1920.

4 SHEETS—SHEET 3.

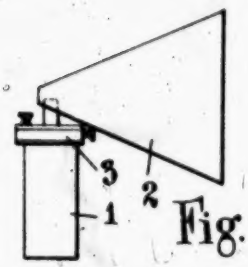


Fig.12.

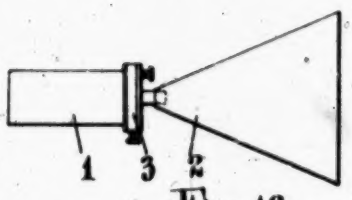


Fig.13.

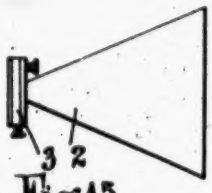


Fig.15.

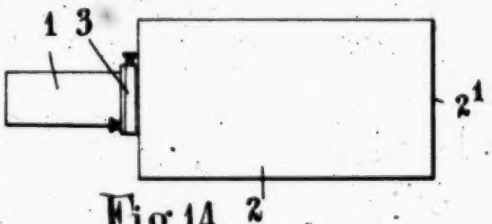


Fig.14.

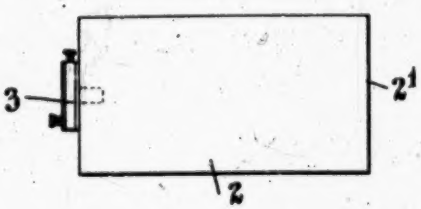


Fig.16.

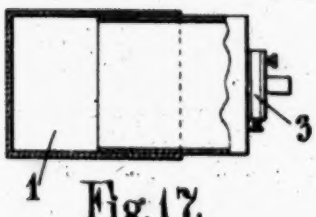


Fig.17.

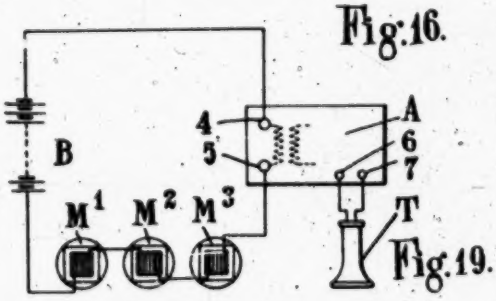


Fig.19.

Fig.18.

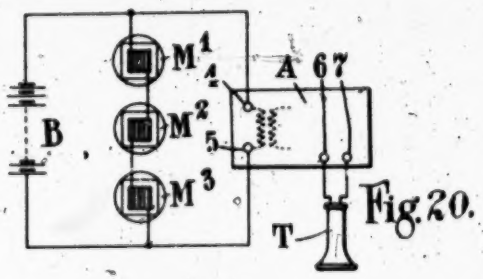


Fig.20.

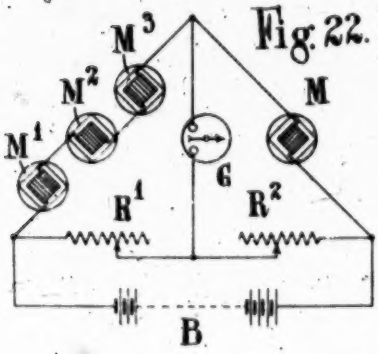


Fig.22.

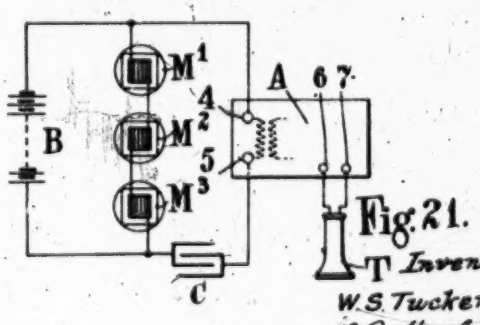


Fig.21.

Inventor
W. S. Tucker
By H. R. Kerslake
Atty

1082

W. S. TUCKER.
SOUND DETECTING DEVICE.
APPLICATION FILED JAN. 6, 1919.

1,351,356.

Patented Aug. 31, 1920.

4 SHEETS—SHEET 4.

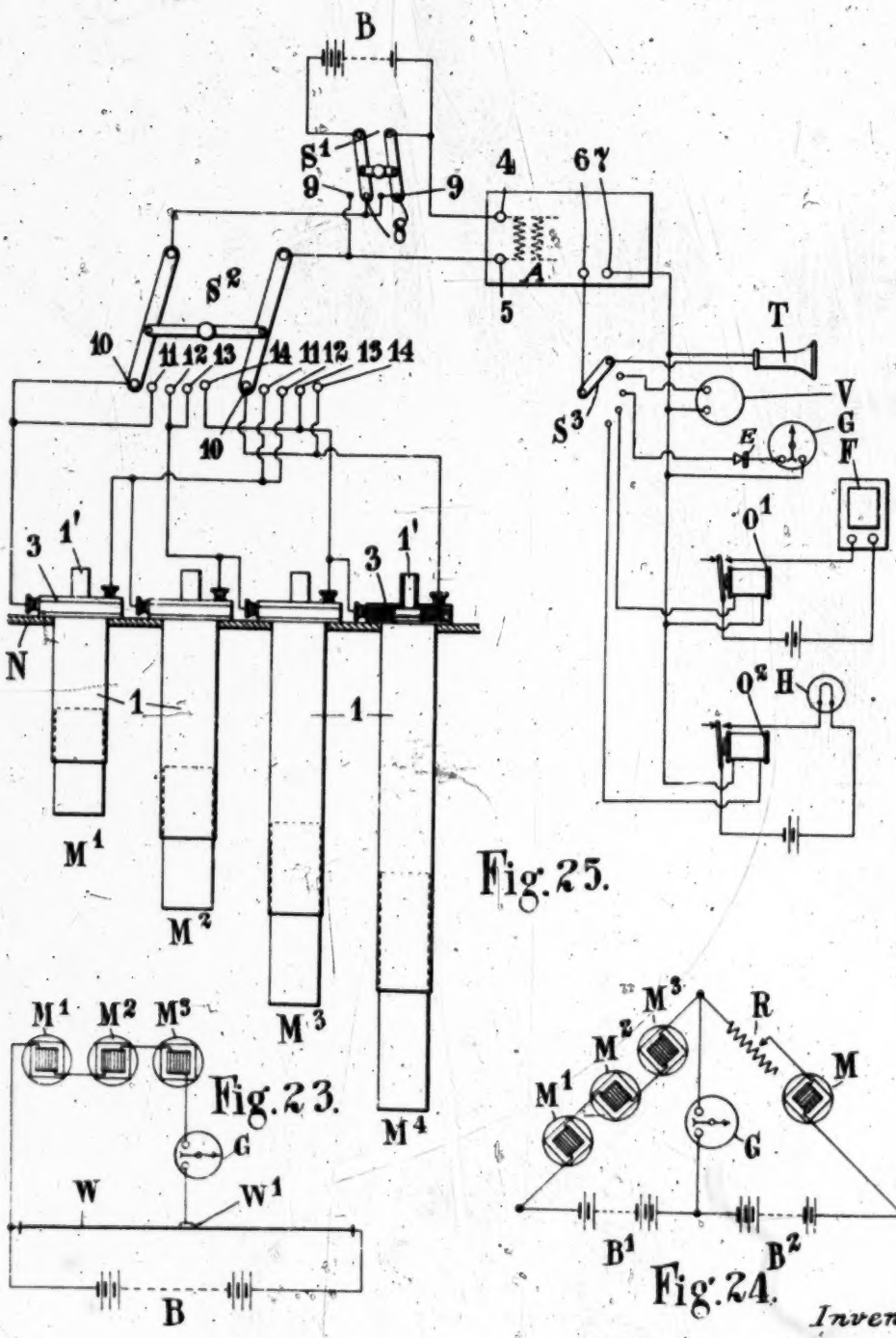


Fig. 25.

Fig. 23.

Fig. 24.

Inventor
W. S. Tucker
By H. R. Kerslake
Atty

UNITED STATES PATENT OFFICE.

WILLIAM SANSOME TUCKER, OF THAMES DITTON, ENGLAND.

SOUND-DETECTING DEVICE.

Specification of Letters Patent. Patented Aug. 31, 1920.

1,351,356.

Application filed January 6, 1919. Serial No. 269,902.

To all whom it may concern:

Be it known that I, WILLIAM SANSOME TUCKER, a subject of the King of Great Britain and Ireland, and residing at Imber Court, Experimental Ground, Thames Ditton, in the county of Surrey, England, have invented certain new and useful Improvements in and Relating to Sound-Detecting Devices, of which the following is a specification.

This invention relates to an improved thermic sound detecting device intended more particularly for determining the position of the origin of a sound produced by the discharge of a gun, although the use of the improved sound detecting device is not limited to such determination or origin, the invention being applicable also to the detection and measurement of such sounds and also to sounds emanating from other origins than from a gun, and being generally useful also for other purposes such as for the measurement of velocity and consequently of the quantity of gases or liquids flowing through tubes or pipes.

Various difficulties have hitherto been encountered with the ordinary type of microphone when used for the purpose hereinbefore more particularly referred to, viz., in conjunction with a sound ranging apparatus for determining the position of a gun. The ordinary type of microphone is more sensitive with regard to sound waves produced by the shell traveling through the air than with regard to those of the actual discharge of the gun and consequently the position of the gun as obtained by means of such a microphone is not accurate and has to be corrected by calculation.

One object of the invention is to provide an improved sound detecting device which responds more readily to the gun report and which overcomes the drawback of having to resort to calculation for obtaining the true position of the gun, other advantages obtained by the use of the sound detecting device constructed according to the present invention being that:—Both gun and sound waves produced by the shell traveling through the air are recorded; a characteristic record is obtained for each sound so that the records produced by the same gun can easily be distinguished from each other and with sufficient experience it can even be ascertained what type of gun has been fired; the sensitiveness of the sound detecting device is constant, and the same does not respond to ordinary noises, nor is it affected by vibration, and it assumes its normal condition immediately after each vibration.

According to the present invention use is made of an electrically heated thin conductor in combination with a sound box and with means for producing a small blast of air past said conductor into the sound box by the effect of the sound or gun wave which it is desired to detect, measure, or record, such detection, measurement, or record being obtained by the variation in the resistance of said electrically heated conductor produced by the cooling effect of the blast upon the conductor.

According to one mode of carrying the invention hereinbefore referred to into effect, a very thin platinum or other suitable wire is mounted close to, preferably in front of or within a small opening which may be made of any desired shape and is provided in the side of a wooden or other box. The wire which may be supported in a suitable frame is connected to terminals and an electric current is passed through it for the purpose of raising its temperature above that of the surrounding air, the temperature of the wire being reduced by the cooling effect of the small blast of air thereon, which is caused by the sound to be determined or recorded.

In all heated conductors having a positive temperature co-efficient the electrical resistance will be reduced by the small blast of air and this variation will depend entirely upon the intensity of the wave and its period will remain constant. It will thus be seen that the record of each sound will show a characteristic wave form determined by the variation in the electrical resistance of the heated conductor.

The variation in the electrical resistance of the heated conductor may be detected and measured by means of an Einthoven string galvanometer or other suitable instrument and permanent records of gun waves or sounds in general may be obtained by means of photographic or other recording devices.

The electrical connections between the sound detecting device and the various detecting, measuring or recording devices may be effected in any suitable manner, either directly or through the intermediary of a suitable coupling, for instance through a

transformer, the latter arrangement being especially useful when it is desired to use the sound detecting device as an automatic transmitter arranged some distance away from the recording instruments.

One mode of carrying the invention hereinbefore referred to into effect is illustrated, by way of example, in Figures 1–11 of the accompanying drawings.

Figs. 1 and 2 are a plan view and a sectional elevation of the improved sound detecting device respectively.

Fig. 3 is a plan view of the support on which the frame carrying the thin conductor is mounted.

Fig. 4 is a plan view of the frame carrying the thin conductor.

Fig. 5 is a plan view of a modified form of construction of the support carrying the frame on which the thin conductor is mounted, while

Fig. 6 is a perspective view of the frame shown in Fig. 5;

Figs. 7 and 8 are a plan view and a sectional elevation of one detail respectively, and

Figs. 9 and 10 are a plan view and a sectional elevation of another detail respectively, while

Fig. 11 illustrates a sub-aqueous sound detecting device.

Figs. 12 to 18 show largely diagrammatically different combined units of sound detecting device and acoustic resonator.

Figs. 19 to 25 illustrate various electrical connections.

Referring to the drawings, Figs. 1 and 2, *a* is a recessed frame of insulating material which is attached to the box *b*, preferably through the interposition of a sheet of india rubber *c*; *d* is a metal disk which is mounted within the frame *a*, preferably through the interposition of an india rubber washer *e*; *f* is a support carrying the frame on which the thin conductor is mounted, as hereinafter more particularly referred to in connection with Figs. 3, 4, 5 and 6; *g* is another metal disk which is attached to the frame *a* and is provided with a tubular extension *h* through which the blast is produced; *i* and *j* are contact terminals which are provided on the metal disks *d* and *g* respectively, and *k* is an insulating washer. The india rubber sheet *c*, the frame *a*, the india rubber washer *e*, the metal disk *d*, the support *f* and the metal disk *g* are provided with central holes to allow the passage of a current of air through the tubular extension *h* provided on the metal disk *g* and past the thin conductor, supported in or closely in front of, or behind the hole of the supporting disk *f*, into the box *b*, through a hole *l* provided in the latter.

Referring to Figs. 3 and 4, the thin conductor *m* is preferably made of Wollaston wire, the silver coated platinum being wound on a small open mica frame *n* preferably formed with teeth *o*, so that the thin conductor may conveniently be wound in a close zig-zag manner, as shown, all the windings lying in one and the same plane. The frame *n* with the thin conductor wound thereon is stuck on or is otherwise attached to the support *f*, which consists of a thin disk of mica provided on each side with an electrode *p* preferably consisting of a thin disk of silver stuck on or otherwise attached to the mica disk *f*, the arrangement being such that the thin conductor *m* lies within or closely in front of, or behind the central hole in the disk *f*. The two ends of the thin conductor *m* are soldered on to the two silver electrodes respectively.

The silver coating on that part of the Wollaston wire which lies in the opening of the frame and is intended to be exposed to the current of air is removed, by first coating the whole of the support *f* with exception of the part of the wire from which the silver is to be removed, with a layer of wax and then dipping the support into nitric acid.

According to the modification illustrated in Figs. 5 and 6, the thin conductor *m* is mounted in a zig-zag manner as shown between two strips or thin bars of insulating material attached to each other and forming a cross bar *q* which is stuck on or is otherwise attached to the mica disk *f* across the opening *f*¹ provided therein, so that the conductor *m* shall lie within or closely in front of or behind the opening in the mica disk. The two ends of the conductor *m* are connected to the two silver electrodes *p* as in the arrangement described with reference to Figs. 4 and 5.

In both forms of construction hereinbefore described, the electrical connection of the thin conductor with the other parts of the circuit or circuits is effected through the two silver electrodes *p* which are in metallic contact with the metal disks *d* and *g* provided with the contact terminals *i* and *j* respectively.

The box *b* on which the sound detecting device hereinbefore described is attached may be formed of two parts which are mounted telescopically, as shown in Figs. 1 and 2, in order to vary the capacity of the box and thereby obtain a resonant effect.

The sound detecting device may also be used as a device for detecting sounds propagated through water, in which case an auxiliary box *b*¹ (see Fig. 11) may be attached to the side of the box *b* carrying the sound detecting device, said auxiliary box being provided, preferably on the side facing the small opening and tubular extension *h* through which the blast is produced, with

a suitable diaphragm b^2 held in position by a ring b^3, by means of which diaphragm any vibrations imparted to the latter from the outside of the box will cause corresponding movements in the air blast past the heated conductor.

The electrical connections between the sound detecting device and the various detecting or equivalent devices are illustrated in connection with the second part of the invention hereinafter referred to.

According to a further feature of the present invention, use is made of a plurality of sound detecting devices, and more particularly of thermic sound detecting devices, each of which is combined with an acoustic resonator of a particular pitch in such a manner that a series of combined sound detecting device and acoustic resonators are obtained, the pitch of which extends along the whole range of acoustic vibrations, or along a portion of such range, according to the object in view.

The arrangement of sound detecting devices having the feature just referred to is more particularly useful in connection with the detection of sound, such as produced by aeroplanes, submarines, or other sources of sound; I wish it, however, to be understood that the invention is not limited to the detection of sound, as it may otherwise conveniently be used, *e. g.*, for the transmission of sound. This part of the invention is diagrammatically illustrated in Figs. 12 to 25.

Referring to Figs. 12 to 16, each combined unit of sound detecting device and acoustic resonator may comprise an open or closed tubular resonator 1 in open communication with a trumpet, or open box 2, with the open end at 2^1, and a thermic sound detecting device 3 inserted between the two, (see Figs. 12, 13 and 14), or a trumpet, or open box 2 with the open end at 2^1 in combination with the sound detecting device 3, the tubular resonator 1 being dispensed with. (See Figs. 15 and 16.)

The tuning of each combined unit of sound detecting device and acoustic resonator to a particular pitch may be either fixed or adjustable; in either case the tuning being attained in a well known manner by the proper adjustment of the shape, length, and volume of the resonating chamber, or of the aperture near the grid of the thermic sound detecting device, or otherwise. Fig. 17 illustrates the method of tuning wherein the volume of the resonating chamber 1 is varied by a telescopic sliding movement, and Fig. 18 the method of tuning wherein the volume of the aperture near the grid of the thermic sound detecting device 3 is varied by a screwing movement, of the tubular extension 1′ within a correspondingly screw-threaded member 1″.

The electrical connection between the thermic sound detecting devices and the other part of the electrical apparatus may be effected in various ways.

In the arrangement illustrated in Fig. 19, the various sound detecting devices M^1, M^2, M^3 are connected in series with each other and with the battery B and the input terminals 4, 5 of the primary of the first stage transformer associated with an amplifier A, the output terminals 6, 7 of which are connected to a telephone T or equivalent device.

The arrangements illustrated in Figs. 20 and 21 differ from that shown in Fig. 19 by the sound detecting devices M^1, M^2, M^3 being arranged in parallel with the battery B and the input terminals 4, 5 of the amplifier; in the case of Fig. 21, a condenser C of suitable capacity is inserted in series with the terminals 4, 5.

Referring to Fig. 22, illustrating a Wheatstone bridge arrangement, M^1, M^2 M^3 are the active sound detecting devices under the influence of the sound which is to be detected, M is a balancing sound detecting device which is not under the influence of the said sound, R^1, R^2 are two adjustable resistances, G is a galvanometer and B the battery.

The Wheatstone bridge arrangement may also be used for discriminating between two sounds of different pitch. In this case the balancing sound detecting device may be rendered operative for a sound outside the range of M^1, M^2, M^3, thus indicating a high pitch aeroplane, as against a lower pitch one, which renders the sound detecting device M^1 operative, the deflections being to the right or to the left, according as to whether the sound comes from the one or the other aeroplane.

Referring to Fig. 23 illustrating the potentiometer method M^1, M^2, M^3 are the sound detecting devices, B the battery, W a wire resistance and G a galvanometer, one end of which is connected to a sliding contact W^1.

Fig. 24 illustrates a compensating arrangement, in which M^1, M^2, M^3 are the active sound detecting devices, M a balancing sound detecting device which is not under the influence of the sound to be detected, R a variable resistance, G a galvanometer and B^1, B^2 two batteries.

Referring to the complete arrangement illustrated in Fig. 25, M^1, M^2, M^3, M^4 are a plurality of combined units of sound detecting device and acoustic resonator, each comprising an open or closed tubular resonator 1 of adjustable length, and a thermic sound detecting device 3 provided with a tubular extension 1′, as hereinbefore described. All these combined units, the number of which may be very large, are mounted on a suitable support N, each one of them being adjusted

to a particular pitch, in order to obtain a range of acoustic vibrations which shall be as wide as possible. The electrical terminals of the various sound detecting devices are connected in series with one another, the two end terminals of the series of sound detecting devices being connected through the intermediary of two switches S^1, S^2, to the battery B and the input terminals 4, 5 of an amplifier A, the output terminals 6, 7 of which are adapted to be connected by means of a switch S^3 to any one of a plurality of indicating or recording devices, viz., a telephone T, a vibration galvanometer V, a rectifying wave detector E associated with a direct reading galvanometer G, and through relays O^1, O^2, to an electric bell F, or lamp H, it being understood that any other indicating or recording device may be used instead.

When the switch S^1 is in the position in which it makes contact with the contacts 8, 8, while switch S^2 is in the position shown in the figure, the sound detecting devices are connected in series with the battery a. with the input terminals 4, 5 of the amplifier, and when it is shifted to the position in which it makes contact with the contacts 9, 9 while switch S^2 remains in the same position, the end terminals of the whole series of sound detecting devices are connected in parallel with the battery and the input terminals 4, 5 of the amplifier. When the switch S^2 is in the position indicated in the figure, in which it makes contact with the contacts 10, 10, all the sound detecting devices are inserted in series with each other in the input circuit of the amplifier. However, by shifting this switch so that it shall make contact with the contacts 11, 11—12, 12—13, 13— and 14, 14, while switch S^1 makes contact with 9, 9, only one of the sound detecting devices is inserted in the input circuit of the amplifier, viz., the sound detecting device M^1, M^2, M^3 or M^4, respectively.

It will thus be seen that when all the sound detecting devices are connected in series with each other, the arrangement will allow of an automatic detection of very faint acoustic vibrations owing to the fact that at least one of the sound detecting devices, namely, that one which happens to be in tune with the vibrations produced by the source of sound will respond to the acoustic vibrations, thereby causing the sound to be detected. Further, if it is desired to concentrate the attention upon a sound having a particular pitch, the sound detecting device unit tuned to such pitch may be connected to the amplifier with the exclusion of all the other sound detecting devices, by means of the switch S^3.

It will also be seen that the sensitiveness of the apparatus will also be increased owing to the fact that in the case of simultaneous acoustic vibrations emanating from the source of sound, several sound detecting devices will simultaneously respond to the different vibrations of respective frequencies, thereby causing an increased variation in the electric circuit.

I wish it to be understood that the mode of carrying the invention into effect and the various details hereinbefore referred to may be modified without in any way departing from the spirit of the invention.

What I claim is:—

1. A sound detecting device comprising an electrically heated thin conductor in combination with a sound box and with means for producing a small blast of air past the electrically heated thin conductor into the sound box, the said conductor being arranged between the said means and the sound box, as and for the purpose set forth.

2. A sound detecting device comprising an electrically heated thin conductor in combination with a sound box having a small opening and with means for producing a small blast of air past the electrically heated thin conductor and small opening into the sound box, the said conductor being arranged between the said means and the said small opening, as and for the purpose set forth.

3. A sound detecting device comprising an electrically heated thin conductor in combination with a sound box having a small opening and with a tubular member through which the blast is produced, the said conductor being arranged between the said small opening and tubular member, as and for the purpose set forth.

4. A sound detecting device comprising in combination an electrically heated thin conductor, a support of insulating material for the said conductor, an opening in the said support across which the said conductor is arranged to lie, a sound box having a small opening, and means for producing a small blast of air past said conductor into the sound box, the said support being arranged with its opening between the small opening in the box and the said means, as and for the purpose set forth.

5. A sound detecting device comprising in combination an electrically heated thin conductor, a support of insulating material for the said conductor, an opening in the said support across which the said conductor is arranged to lie, two thin metal disks attached to the latter support, an opening in each of the thin metal disks facing the opening in the said support, the two ends of the thin conductor being electrically connected to the two thin metal disks respectively, a sound box having a small opening, and means for producing a small blast of air past said conductor into the sound box,

the said support being arranged with its opening between the small opening in the box and the said means, as and for the purpose set forth.

6. A sound detecting device comprising in combination an electrically heated thin conductor, an open frame of insulating material, teeth on the said frame for the reception of the thin conductor, and means for producing a small blast of air past said conductor into the sound box, as and for the purpose set forth.

7. A sound detecting device comprising in combination an electrically heated thin conductor, a support of insulating material for the said conductor, an opening in the said support, two thin metal disks attached to the latter support, an opening in each of the thin metal disks facing the opening in the said support, the two ends of the thin conductor being electrically connected to the two thin metal disks respectively, two metal plates in metallic contact with the two thin metal disks respectively, openings in the metal plates opposite the opening in the support of insulating material, a sound box, and means for producing a small blast of air past the thin conductor into the sound box, as set forth.

8. A sound detecting device comprising in combination an electrically heated thin conductor, a support of insulating material for the said conductor, an opening in the said support, two thin metal disks attached to the two ends of the thin conductor being electrically connected to the two thin metal disks respectively, two metal plates in metallic contact with the two thin metal disks respectively, openings in the metal plates opposite the opening in the support of insulating material, contact terminals on the two metal plates, a sound box and means for producing a small blast of air past the thin conductor into the sound box, as set forth.

9. A sound detecting device comprising in combination an electrically heated thin conductor, a support of insulating material for the said conductor, an opening in the said support, two thin metal disks attached to the latter support, an opening in each of the thin metal disks facing the opening in the said support, the two ends of the thin conductor being electrically connected to the two thin metal disks respectively, two metal plates in metallic contact with the two thin metal disks respectively, openings in the metal plates opposite the opening in the support of insulating material, a tubular member on one of the metal plates in communication with the opening therein, and a sound box, as set forth.

10. A sound detecting device comprising a sound box, a small opening in the latter, a frame attached to the sound box, a small opening in the said frame, an electrically heated thin conductor, a support of insulating material for the said conductor, an opening in the said support, two thin metal disks attached to the latter support, an opening in each of the thin metal disks facing the opening in the said support, the two ends of the thin conductor being electrically connected to the two thin metal disks respectively, two metal plates in metallic contact with the two thin metal disks respectively, and openings in the metal plates opposite the opening in the support of insulating material, the latter support with the thin conductor thereon and with the two metal disks attached thereto, together with the metal plates, being mounted on the frame attached to the sound box, as set forth.

11. A sound detecting device comprising an electrically heated thin conductor in combination with a sound box having a small opening, the volume of which sound box is capable of being varied, and with means for producing a small blast of air past the electrically heated thin conductor into the sound box, the said conductor being arranged between the said means and the said small opening, as and for the purpose set forth.

12. In combination a plurality of differently tuned sound detecting devices, each sound detecting device comprising an electrically heated thin conductor, a sound box having a small opening, and means for producing a small blast of air past the electrically thin heated conductor into the sound box, the said conductor being arranged between the said means and the said small opening, and the plurality of sound boxes being capable of being adjusted so as to have different volumes, thereby constituting a series of open resonators of different pitch as and for the purposes set forth.

In testimony whereof I have signed my name to this specification.

WILLIAM SANSOME TUCKER.

1089 To 1094.

1671 1089

DEFENDANT'S EXHIBIT O-7

Williams Patent No. 1,671,262

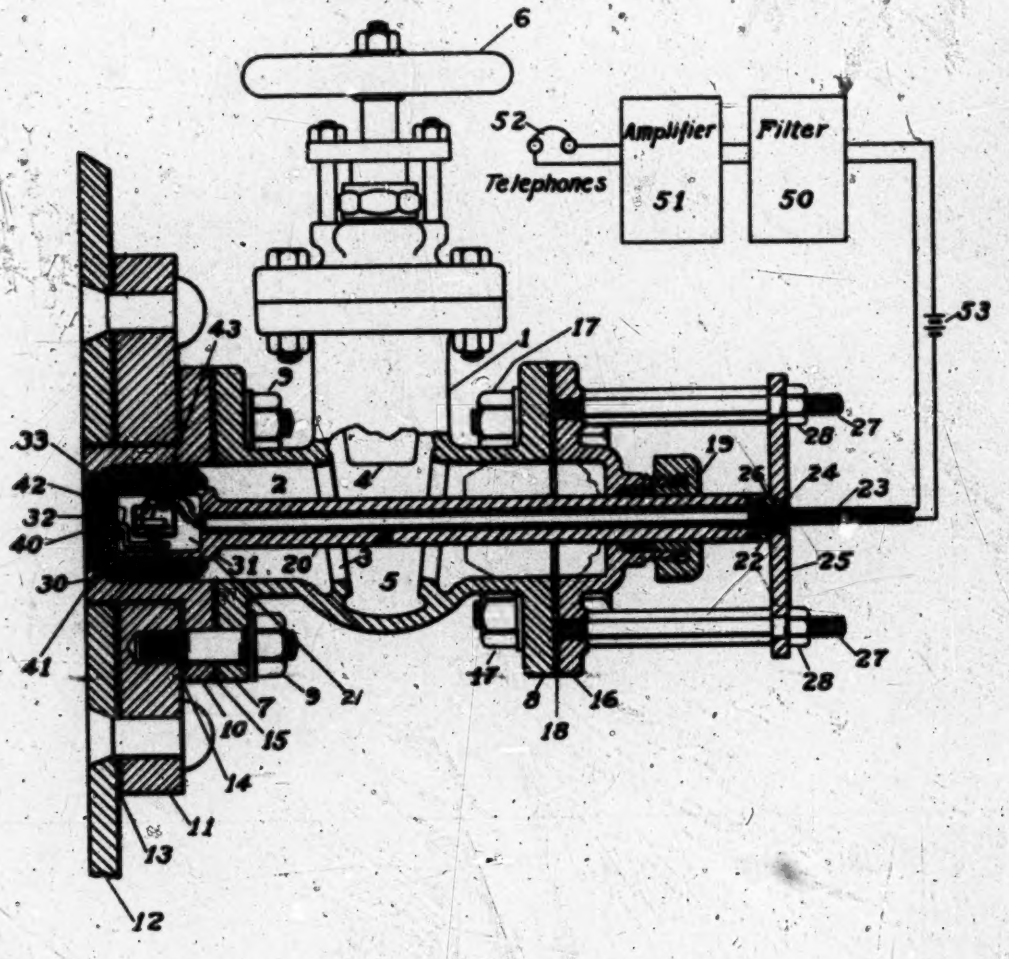
[Endorsed]: Filed Nov. 4, 1942.

May 29, 1928. 1,671,262

R. L. WILLIAMS

SUBMARINE SOUND RECEPTION

Filed April 2, 1925



INVENTOR.
ROBERT L. WILLIAMS
BY Ezekiel Wolf
ATTORNEY.

Patented May 29, 1928.

1,671,262

UNITED STATES PATENT OFFICE.

ROBERT LONGFELLOW WILLIAMS, OF NEWTON, MASSACHUSETTS, ASSIGNOR TO SUBMARINE SIGNAL CORPORATION, OF BOSTON, MASSACHUSETTS, A CORPORATION OF DELAWARE.

SUBMARINE SOUND RECEPTION.

Application filed April 2, 1925. Serial No. 20,227.

The present invention relates to an improvement in submarine sound reception and comprises mainly a skin mounted aperiodic receiver in a special valve within a ship and conveying the signals received to a listener through a circuit designed for selective reception.

One of the objects of the present invention is to present a suitable removable mounting and removable aperiodic receiver which can be changed without the necessity of the ship going into dry dock.

Another feature of the present invention is to surround the actuated diaphragm of the receiver by such an inertia mass that the vibrations of the ship will have little effect upon exciting the diaphragm or the microphone connected therewith.

A further feature of the present invention is the combination of an aperiodic receiver with a filter and amplifying circuit which presents distinct advantages in the selective reception of submarine sound waves.

Other features of the present invention will be learned from the description in the specification and the drawing in which the figure shows a part sectional view of the receiver and the circuit used for reception.

The receiver is, of course, installed under the water line of the vessel where the diaphragm will be continually adjacent to the water.

In the figure, 1 indicates the valve proper which consists of a hollow cylinder 2, with a gate opening 3, behind which the plunger 4 is adapted to move into a seat 5 to close the rear of the cylinder from the outer water. This is accomplished by turning the hand wheel 6. Both ends of the gate valve are provided with flanges 7 and 8.

The front flange 7 is bolted to a composition seat 10 by means of machine screws 9, 9, which pass through the latter and thread into a heavy inertia ring 11 rigidly riveted to the ship's plate 12. Between the ship's plate and inertia ring is a suitable gasket 13, and likewise the composition seat 10 and the flange 7 are provided with suitable gaskets 14 and 15, the former between pieces 10 and 11, and the latter between pieces 7 and 10.

The rear end of the cylinder 2 is closed in the following manner. A cap 16 is firmly clamped to the flange 8 by bolts 17, 17. Between 8 and 16 is a suitable gasket 18. A stuffing box 19 of usual construction closes the opening in the cap 16, through which the stem 20 passes.

At one end of the stem 20 is the receiving apparatus 21 which will be described shortly. At the opposite end of the stem 20 is a cap 22, forming part of a clamping means to hold the cable 23 in position so that no strain will be placed upon the wires within the stem 20. The cap 22 is threaded at 24 to receive the piece 25 which normally bears against a shoulder 26 of the cap 22. Near the edge of the piece 25 are studs 27, 27 and nuts 28, 28 threading thereon, the studs 27 threading into the piece 16 and the nuts 28 serving to hold the piece 25 firmly against the shoulder 26 of the stem 20. In this way the receiver 43 is held firmly in place.

The receiver 21 consists of a rubber shell 30 having an opening in the back and a recess 31. The front is formed of a diaphragm 32 with a beveled edge 33 which through the pressure exerted by the piece 25 upon the stem 20 rests firmly in the bevel of the piece 10. Moulded in the rubber diaphragm 32 is a stud 40 with a threaded end 41 capable of receiving the rod 42 holding the microphone receiver 43, which can be attached to the former.

Two wires of the microphone receiver pass to the cable 23 within the stem 20. The cable 23 leads to a filter circuit 50, which transmits the signal to an amplifying circuit 51 and then to the telephone receivers 52. The battery 53 is shown in the microphone circuit.

The operation of the apparatus is obvious and therefore needs little explanation. The incoming signal vibrating the diaphragm causes a change of resistance in the microphone in the usual manner which is transmitted to the filter and finally heard in the telephone.

In particular the rubber diaphragm is practically aperiodic so that it is equally sensitive to all frequencies. As the result of this the low frequency water noises actuate the diaphragm at their own frequency. This

is not true of a highly tuned diaphragm. In the latter case the low frequency noises, which are apt to be of greater intensity than the incoming signal, actuate the tuned diaphragm by impact excitation. In this case the water noises are already transformed in frequency to that of the signal which, of course, is tuned to the natural frequency of the diaphragm, when actuating the microphone. In such a case a filter would pass through the noises if it passed through the signal, and would therefore be of no purpose at all. The aim of the present system is to preserve the characteristic frequencies of the incoming disturbances and filter the bands in which these frequencies occur so that only the incoming signal is transmitted to the amplifying circuit. In this manner all opportunity of the incoming disturbing noises operating the amplifier by impact excitation is also avoided. The present system while sensitive to very weak noises and signals is practically free from disturbances of the former, after the signals have been filtered and amplified.

In addition to this feature the ship's noises are practically entirely excluded by the loose coupling effected between the microphone and the ship's plate. This is effected by means of the large inertia plate 11, which is rigidly riveted to the skin of the vessel, by the composition seat 10 and by the rubber shell 30, which only sets snugly but not rigidly in the composition seat. The mass of the diaphragm which is exceedingly small being made of the rubber which is of low specific gravity is only loosely connected with a very large inertia mass of iron of high specific gravity, the combination of which may be shown both mathematically and experimentally to be of the very loosest coupling. The result is, therefore, that very little of the ship's vibrations is transmitted to the diaphragm and these therefore are entirely excluded from the system. This is especially advantageous since the vibrations, due to the ship's noises, may be of almost any frequency, depending upon the kinds of apparatus used upon the ship.

In addition the composition seat serves another function. As it will not corrode and is only bolted to the inertia plate, it can easily be removed when the ship is in dry dock. This is an advantage over former systems used.

In describing the microphone receiver 43 above, it should have been remarked that the present installation is adapted to be installed in the bottom of the vessel. In this position the button itself, that is the plane of the electrodes, will be vertical so that the granular carbon which lies loose between the electrodes can come in contact with both electrodes and make a good electrical circuit. The installation is such that whatever position the diaphragm 32 is in, the microphone is in a vertical position. This is accomplished by bending the stem 42 in such a manner that the button is always vertical.

Having now described and explained the features of my invention, I claim:

1. In combination a vessel having an opening in its skin, a soft rubber shell having a diaphragm wall with a plane outer portion and a peripheral seat, a microphone, means mounting said microphone on said diaphragm wall and means mounting said shell in said opening in the skin with the outer diaphragm wall flush with the outer skin surface, including a large inertia member about said opening and a portion having a seat cooperating with said shell seat.

2. In combination a vessel having an opening in its skin, a soft rubber shell having a diaphragm wall with a plane outer portion and a peripheral seat, a microphone, means mounting said microphone on said diaphragm wall and means mounting said shell in said opening in the skin with the outer diaphragm wall flush with the outer skin surface, including a large inertia member permanently secured to the skin surrounding said opening and a seat member bolted to said inertia member in which said shell rests.

3. In combination a vessel having an opening in its skin, a soft rubber shell having a diaphragm wall with a plane outer portion and a peripheral seat, a microphone, means mounting said microphone on said diaphragm wall and means mounting said shell in said opening in the skin with the outer diaphragm wall flush with the outer skin surface including an inertia member in which said shell sets secured to the skin and means for maintaining said shell firmly in said inertia member.

4. In combination a vessel having an opening in its skin, a soft rubber shell having a diaphragm wall with a plane outer portion and a peripheral seat, a microphone, means mounting said microphone on said diaphragm wall and means mounting said shell in said opening in the skin with the outer diaphragm wall flush with the outer skin surface including an inertia member surrounding said opening and a removable seat member bolted to said inertia member in which said shell rests.

5. In combination a vessel having an opening in its skin, a soft rubber shell having a diaphragm exposed to the outer water adjacent to said opening, a microphone, means mounting said microphone on said diaphragm and means mounting said shell in said opening in the skin with the outer diaphragm wall flush with the outer skin surface, including a large inertia member about said opening and a portion having a seat cooperating with said shell seat.

6. In combination a vessel having an opening in its skin, a soft rubber shell having a part formed as an aperiodic diaphragm exposed to the outer water adjacent to said opening, a microphone, means mounting said microphone on said diaphragm and means mounting said shell in said opening in the skin with the outer diaphragm wall flush with the outer skin surface, including a large inertia member about said opening and a portion having a seat cooperating with said shell seat.

In testimony whereof I affix my signature.

ROBERT LONGFELLOW WILLIAMS.

DEFENDANT'S EXHIBIT O-9

Taylor Patent No. 1,847,636

[Endorsed]: Filed Nov. 4, 1942.

1096

March 1, 1932. J. B. TAYLOR 1,847,636

VIBRATION RECORDING AND REPRODUCING APPARATUS

Filed Nov. 28, 1927

Fig. 1.

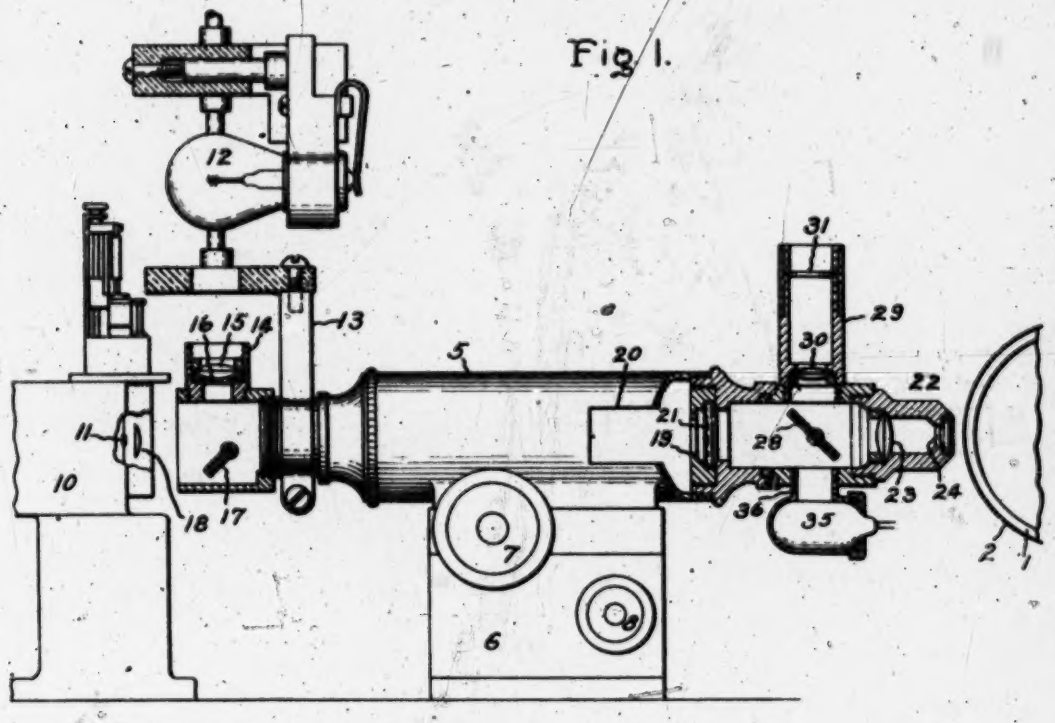
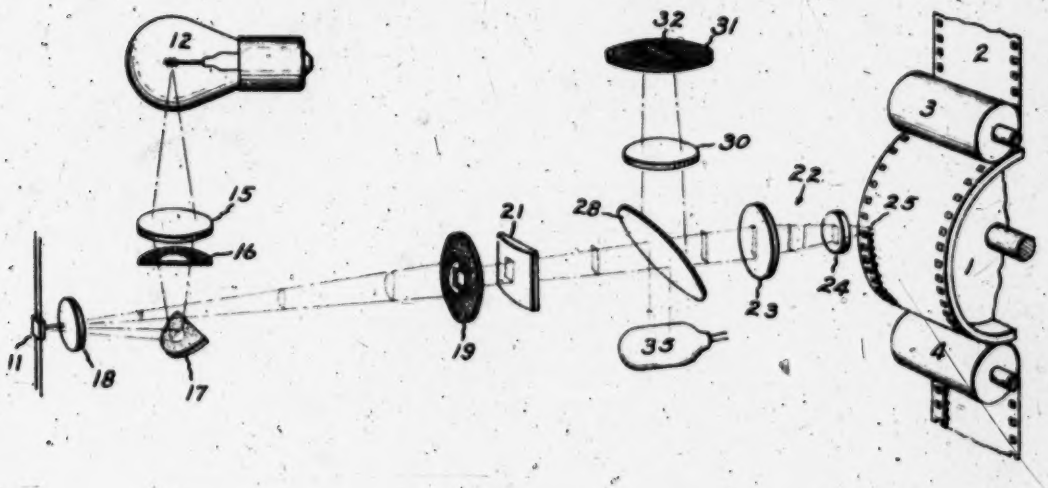


Fig. 2.



Inventor
John B. Taylor,
by Alexander Sinclair
His Attorney.

Patented Mar. 1, 1932

1,847,636

UNITED STATES PATENT OFFICE

JOHN B. TAYLOR, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK

VIBRATION RECORDING AND REPRODUCING APPARATUS

Application filed November 28, 1927. Serial No. 236,045.

My invention relates to apparatus for photographically recording vibrations on a light sensitive member and to apparatus for reproducing vibrations from a record thereof. My invention relates particularly to apparatus for making the photographic record in the form of a band on a moving film by means of a beam of light which is caused to vary in accordance with the vibrations to be recorded.

For the faithful recording of vibrations having relatively high frequencies, such for example as are represented by the overtones in certain sound waves, and for the true reproduction of such vibrations previously recorded, for example, on a film it has been found that with moderate film speeds the light beam employed in either case must be extremely narrow where it engages the film. In apparatus heretofore constructed, a beam having the necessary narrowness usually has been obtained by the use of a screen having an aperture therein of the order of one mil in width arranged close to the moving film. Arrangements also have been proposed wherein a screen displaced from the film and having a larger aperture is used and by the use of suitable lenses a reduced image of the aperture is formed on the film. With such forms of apparatus I have found it difficult in certain cases to obtain sufficient light intensity on the film and where an aperture of microscopic width is used close to the film many other difficulties are met with in the construction and the operation of the apparatus. It is an object of my invention, therefore, to provide improved apparatus of this character which shall avoid difficulties experienced in the construction and use of former apparatus, shall be efficient and shall include means which facilitate the adjustment and use of the apparatus.

In accordance with one feature of my invention I dispense with the use of narrow apertures either arranged close to the moving light sensitive member or at a distance therefrom and employ optical means for bending the rays from a suitable light source to form a line of light on the light sensitive member having the desired intensity and the desired narrow width.

My invention will be better understood from the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

Referring to the drawings, Fig. 1 is a side elevation, partly in section, of apparatus involving my invention and Fig. 2 shows the optical system of the apparatus.

Certain features of my invention relate to apparatus for making a photographic record on a moving light sensitive member while other features relate both to such apparatus and to apparatus for reproducting vibrations previously recorded. In the drawings illustrating my invention, I have shown apparatus for recording electrical vibrations on a moving film by means of an oscillograph galvanometer. This apparatus is of the type wherein by optical means a line of light is focused on the film as distinguished from the type employing a mechanical slit or light aperture arranged close to the moving film. On the drawings I have shown the film supported on the face of a rotatable drum. Such a drum I have shown at 1, the film 2 as seen in Fig. 2, passing between the drum and the idlers 3 and 4. Tube 5 carrying the main portion of the optical system is adjustably mounted on the base 6 whereby it may be given the various movements necessary to properly position the line of light on the film. I have shown only the adjusting screws 7 and 8 for effecting respectively the coarse and fine adjustment of the tube longitudinally. Adjacent the end of the tube 5 further from the film is the oscillograph galvanometer 10 having the small mirror 11 and having means for effecting various adjustments thereof. In use, the oscillograph galvanometer is electrically connected with a source of electrical vibrations to be recorded. If the apparatus is to be used to record sound, a sound pick-up device, such for example as a condenser microphone, may be connected to the oscillograph galvanometer preferably through a suitable amplifying device. The source of light comprising the incandescent lamp 12 is shown mounted on one end of tube 5 by means of the bracket 13, suitable adjustments being

provided for properly positioning the lamp. In the lateral branch 14 of tube 5 is the lens 15 and the diaphragm 16, the latter, as shown more clearly in Fig. 2, having a straight edge whereby a portion of the light beam from lens 15 is shut off. The purpose of the diaphragm is to give a sharp edge to that part of the light beam which finally reaches the film. Below the lens and diaphragm and offset from the center of the tube 5 is the adjustable mirror 17 set at approximately 45° so as to reflect the light beam to the oscillograph mirror 11. I have shown this mirror 17 semicircular in shape, this form being used for convenience in avoiding interference with the beam after reflection from the oscillograph mirror. I have also shown the lens 18 mounted immediately in front of the oscillograph mirror through which lens pass both the incident and the reflected beams. To facilitate the proper positioning of the beam of light reflected from the oscillograph mirror, I have shown the target 19 having a square opening therein mounted near the other end of the tube and for observing the position of the beam on the target a suitable opening 20 is provided in the wall of the tube. Adjustments are made to bring the straight side of the bright spot corresponding to the sharp edge of the beam approximately at the middle of the opening in the target. That portion of the beam which passes through the target first traverses the cylindrical lens 21 which is arranged with its axis vertical or at right angles to the vibratory movement of the beam. Beyond the cylindrical lens 21 is the lens system 22 shown as comprising lenses 23 and 24 which in cooperation with the cylindrical lens 21 arranged in the manner described refract the rectangular light beam passing the target into a beam which focused on the film, produces a very narrow bright line of light 25. The lens system 22 would focus the beam to a point-like spot on the film; the cylindrical lens 21 spreads the spot transversely of the film to a line of light. As the beam is vibrated in response to vibrations of the mirror 11, the length of the bright line 25 varies accordingly, the end of the line which moves being sharply defined whereby as the film advances with a steady movement it is exposed in a manner to form a serrated edge record thereon. For the lens system 22 I have found it convenient to employ a microscope objective, of suitable equivalent focus and numerical aperture, with which a bright line of the required length and having a width of 1 mil, more or less, is readily obtained.

For the purpose of better enabling the operator to focus and position the line of light on the film I have provided the apparatus with means for viewing a magnified image of the light line. In the present embodiment of my invention, I have shown within the tube 5 and between the cylindrical lens and the lens 23 a thin piece of glass 28, su as a piece of cover glass, arranged at angle approximately of 45° and opposite th glass in a branch tube 29 I have shown t lens 30 and the screen 31 which for examp may be a piece of ground glass. A certa small portion of the light reaching the fil in the light line 25 will be reflected from t film surface and a part of this reflected ligh after passing back through the lens system is partly reflected by the inclined glass through the lens 30 on the screen 31 whe it forms an enlarged image 32 of the ligh line 25 on the film.

Such an enlarged image of the light lin is of great assistance to the operator. enables him continuously to check and mai tain the proper focus and position of the ligh line during the process of recording and provides a constant visual indication of th deflection amplitude and of the film actio as for example the presence of film on th drum or the absence thereof due to runnin out of breakage. A reference line or line scratched or otherwise marked on the scree 31 facilitate the quick and accurate adjust ment of the apparatus to properly positio the light line on the film.

While I have illustrated my invention a comprising an arrangement for making a ser rated edge or variable width record it is no limited to the making of such records but i also adapted for making records of the con stant width variable density type. If such record is to be made the oscillograph galva nometer will be rotated 90° so as to assume horizontal position in the form illustrate and the diaphragm will be rotated 90° on th axis of the light beam passing therethrough With the construction illustrated it may b found more desirable to rotate the entire as sembly including the lamp 12, lens 15, dia phragm 16 and mirror 17 instead of the dia phragm only. This will rotate the beam reaching the target 19 through 90° and caus it to vibrate in a vertical plane, thereby vary ing the amount of light passing through th target to the film. The length of the ligh line 25 now remains constant but the bright ness of the line varies with the deflections o the oscillograph mirror whence the film is ex posed in a band of constant width and vari able intensity longitudinally.

For monitoring the recording operation particularly where sound is being recorde the operator may be provided, for example wth a head set connected in circuit with th oscillograph galvanometer or with the sound pick-up device. This, however, does not tak into account the operation of the oscillograph galvanometer and the optical system. I hav provided therefore a monitoring device com prising the photo-electric cell 35 arranged a the end of the lateral tube 36 opposite the tub

29 and the glass 28. Although most of the light beam which is vibrated by the oscillograph mirror and which passes through the target 19 will pass on through the glass 28 to the film a certain small proportion of it will be reflected laterally into the cell 35. By connecting the cell to the operator's telephone preferably through a suitable amplifying device he is able to supervise the operation of the entire apparatus by hearing and judging the intensity and quality of the musical or other sounds being recorded.

While I have shown and described my invention as comprising a recording apparatus, certain portions thereof, namely, the optical system including the cylindrical lens 21 and the lens system 22 and also the apparatus for viewing the light line, are also applicable for use in a reproducing apparatus. In the latter case it is understood that the light beam is not vibrated and a suitable photo-electric cell is arranged behind the film whereby the amount of light reaching the cell is controlled by the record on the film.

I have chosen the particular embodiment described above as illustrative of my invention and it will be apparent that various modifications may be made without departing from the spirit and scope of my invention which modifications I aim to cover by the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. Apparatus for recording vibrations on a moving light sensitive member comprising a source of light from which a beam is directed toward said member, means for vibrating said beam transversely of the movement of said member in accordance with the vibrations to be recorded, means in the path of said beam adapted to focus the beam to a point-like spot of light on the member and means for spreading the beam to form in cooperation with the focusing means a thin line of light on the member.

2. Apparatus for recording vibrations comprising a light sensitive member supported for longitudinal movement, a source of light, means responsive to said vibrations for vibrating a beam from said source transversely of the movement of said member, and means comprising a cylindrical lens having its axis at right agles to the direction of movement of the beam for bending the rays of the beam, to form a narrow transverse line of light on said film.

3. Apparatus for recording vibrations comprising a film supported for longitudinal movement, a source of light, means responsive to said vibrations for directing a beam from said source toward said film and for vibrating the beam transversely of said film movement, a cylindrical lens arranged in said beam having its axis extending in the direction of the movement of the film, and a reducing lens system between the film and the cylindrical lens.

4. Apparatus for recording vibrations comprising a light source, a mirror adapted to be vibrated in accordance with the vibrations to be recorded, means for directing a beam of light from said source on said mirror, a diaphragm arranged to give the beam a sharp edge at one side thereof, a film supported for longitudinal movement in a direction at right angles to the vibratory movement of the light beam reflected from said mirror, and means comprising a cylindrical lens having its axis extending in the direction of the film movement for bending the rays of said reflected light beam to form a narrow transverse line of light on the film.

5. Film sound recording apparatus comprising a light source, an oscillograph galvanometer having a mirror adapted to be vibrated in accordance with the sound waves to be recorded, a mirror for directing a light beam from the source to the oscillograph galvanometer mirror, a diaphragm arranged to give the beam a sharp edge at one side thereof, a lens arranged close to the oscillograph galvanometer mirror through which pass the incident and reflected beams, a film, a drum for supporting and moving the film longitudinally at right angles to the vibratory movement of the reflected beam, and means for refracting the rays of the reflected beam to form a narrow transverse line of light on the film, comprising a cylindrical lens having its axis at right angles to the direction of movement of the reflected beam and a microscope objective adjacent the film.

6. In apparatus for recording vibrations on a film or for reproducing vibrations from a film record, a movable film, means for projecting a beam of light toward the film, a lens system for producing a narrow line of light on the film traversed by said beam comprising a cylindrical lens having its axis at right angles to the said narrow line and a spherical lens, a reflecting member arranged in the beam between said lenses, and a viewing screen upon which an enlarged image of said line of light is reflected by said member.

7. In apparatus of the character described, a movable film, a source of light, and means for focusing light from the source in a narrow band on the film comprising a cylindrical lens having its axis at right angles to the band and a spherical lens between the film and the cylindrical lens.

8. Film sound recording apparatus comprising a film supported for longitudinal movement, means for projecting toward said film a beam of light variable in accordance with the sound to be recorded, a photo-electric device and means arranged in the path of said beam for partially reflecting it to said photo-electric device.

9. Film sound recording apparatus com-

prising a film supported for longitudinal movement, means for projecting a light beam toward said film, means for vibrating said beam in accordance with the sound to be recorded, a photo-electric cell arranged adjacent said beam, and a member arranged in said beam constructed partially to reflect the rays thereof into said cell.

10. A device for approximately uniform illumination of a slit-shaped field, containing a source of light, a cylindrical lens system of collective effect, whose cylindrical axis is perpendicular to the longitudinal axis of the slit-shaped field, and a spherical lens system of collective effect disposed behind the cylindrical system, the cylindrical system being adapted to project in the main section perpendicular to its cylinder axis, approximately in the entrance pupil of the spherical system, an image of the source of light, and the spherical system being adapted to alone project an image of the source of light approximately in the plane of the field to be illuminated.

11. A device for approximately uniform illumination of a slit-shaped field, containing a source of light, a cylindrical system of collective effect, whose cylindrical axis is perpendicular to the longitudinal axis of the slit-shaped field, and a spherical system of collective effect disposed behind the cylindrical system, the cylindrical system having a diameter allowing the passage of all those rays which are emanated from any point of the source of light to any point of the periphery of the entrance pupil of the spherical system, and being adapted to project in the main section perpendicular to its cylinder axis, approximately in the entrance pupil of the spherical system, an image of the source of light, which is at least as long as the diameter of the said entrance pupil, and the spherical system being adapted to alone project an image of the source of light approximately in the plane of the field to be illuminated.

12. Film sound recording apparatus comprising a film supported for longitudinal movement, means for projecting toward said film light variable in accordance with the sound to be recorded, a photoelectric device and means arranged in the path of said light for partially reflecting it to said photoelectric device.

13. In combination with an optical system for focusing a minute luminous image upon a film sound record, a cylindrical lens so positioned in relation to the remainder of the system as to spread the minute luminous image laterally of the sound record into a linear image.

In witness whereof, I have hereunto set my hand this 25th day of November, 1927.

JOHN B. TAYLOR.

PLAINTIFF'S EXHIBIT No. 18

Lehr & Wyatt Patent No. 2,047,974

[Endorsed]: Filed Nov. 4, 1942.

July 21, 1936. P. E. LEHR ET AL 2,047,974

METHOD AND APPARATUS FOR MEASURING WELL DEPTHS

Filed Nov. 1, 1933

Fig. 1

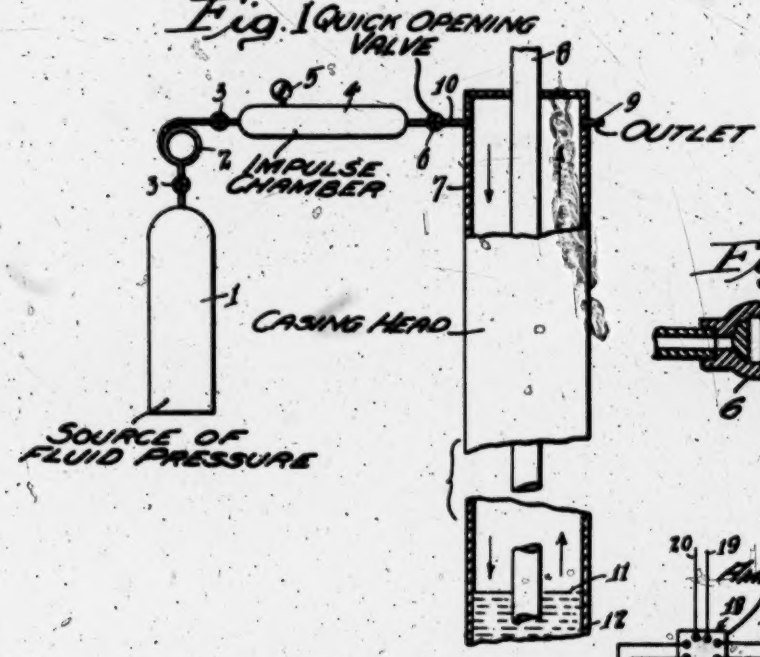


Fig. 4

Fig. 2

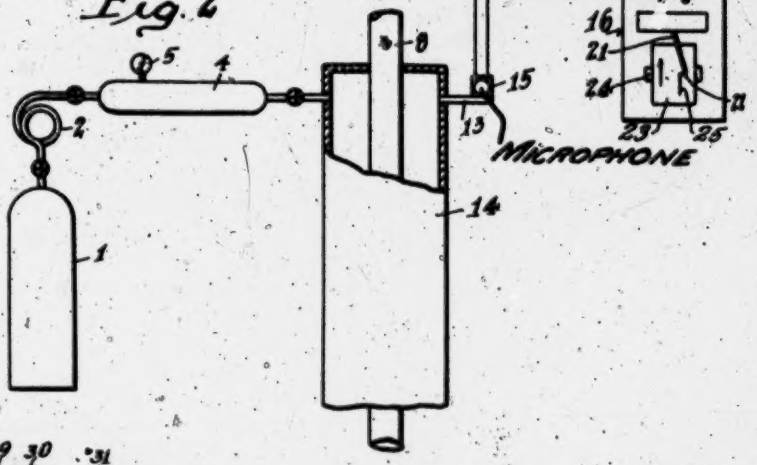
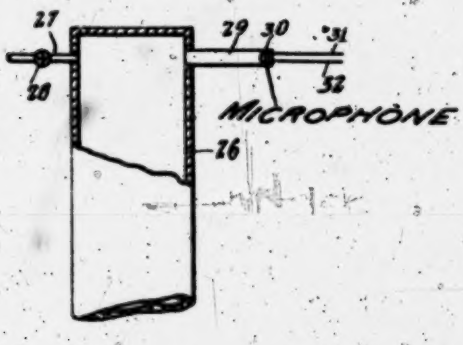


Fig. 3



Inventor

Harold S. Kyatt
Paul E. Lehr

By Lyon & Lyon

Attorneys

UNITED STATES PATENT OFFICE

2,047,974

METHOD AND APPARATUS FOR MEASURING WELL DEPTHS

Paul E. Lehr and Harold T. Wyatt,
Long Beach, Calif.

Application November 1, 1933, Serial No. 696,290

9 Claims. (Cl. 177—352)

This invention relates to a method and apparatus for measuring distances and while the invention may be employed for different specific purposes, it is intended to be used particularly for measuring the depth of deep wells.

The usual method of measuring a well depth is by means of a sand line or a similar line let down into the well. This consumes considerable time and labor.

It has been attempted to measure the depth of wells by using a sound wave method in accordance with which a sound is made at the mouth of the well and then the elapsed time is measured for this sound wave to pass to the bottom of the well and be reflected back to the mouth of the well. The sound wave method operates more perfectly in theory than in practice for the reason that there is really very little energy in a sound wave and in deep wells this energy becomes so dissipated that the recording of the elapsed time becomes difficult. In using the sound method referred to, perhaps the crookedness of the well hole has considerable to do with the dissipation of the energy of the sound, causing considerable reflection and partial absorption of the sound waves as they pass down the well and return.

The general object of this invention is to provide a simple method and simple apparatus for ascertaining the distance to a distant surface from a local point, and particularly the distance from a well head to the liquid surface at the bottom of the well. It is frequently desirable during operations to ascertain the depth of the well measured to the surface of the liquid at its bottom and it is also frequently necessary to have this information in connection with pumping wells. The present method and apparatus affords means for determining well depths without the use of a sand line, and saving considerable labor; and without the use of a "sound method" which is more or less unreliable.

The invention may be practiced to advantage in shut down fields where it is important that a systematic series of fluid level observations be taken in order to locate those wells where the casing has failed and allowed water to enter.

Further objects of the invention will appear hereinafter.

As regards the apparatus, the invention consists in the novel parts and combination of parts to be described hereinafter, all of which contribute to produce an efficient apparatus for measuring well depths.

As regards the method, the invention consists in those novel steps and combinations of steps to be described hereinafter, all of which contribute to produce an efficient method for measuring well depths.

A preferred embodiment of the invention is described in the following specification, while the broad scope of the invention is pointed out in the appended claims.

In the drawing:

Figure 1 is a diagrammatic view illustrating a simple form of apparatus which may be employed in practicing the invention. This view shows some of the apparatus in side elevation and shows a portion of a well casing partly in elevation and partly in section, with certain parts broken away;

Figure 2 is a view similar to Figure 1 but illustrating indicating or recording apparatus for producing a record of the elapsed time in making the test;

Figure 3 is a view similar to Figure 2 but illustrating simple apparatus for enabling the invention to be practiced where the well is under pressure;

Figure 4 is a longitudinal section through a quick opening valve or cock which may be of conventional type and which is employed in connection with the invention.

Before proceeding to a detail description of this invention, it should be stated that it employs the impulse wave principle, and the impulse wave is not generated by sound, but is generated by causing a sudden change in pressure at the well head. This change in pressure may be occasioned by a sudden liberation of a sufficient quantity of gas at the well mouth to cause a sudden substantial increase of pressure or a sudden decrease of static pressure within the well head, and it may be accomplished so that only a slight change in pressure at the local point results. In either case this produces a pressure impulse wave immediately at the well head; and the elapsed time is observed for this wave to traverse the space from the local point or well head, to an obstruction such as liquid in the well, and return to the well head. If the well is not under pressure, we prefer to employ a confined quantity of fluid, preferably gas, and suddenly liberate a small quantity of it into the well head.

If the well has considerable pressure in it, as frequently exists in gas wells, the invention can be practiced by allowing a quantity of gas at the well head to escape suddenly into the atmosphere. If this is done, an expansion wave immediately originates at the well head, passes down to the

surface of the liquid at the well bottom, and then travels up to the well head.

The elapsed time may be observed or indicated in any desired manner. If it is not desired to employ indicating instruments or recording instruments, a simple outlet can be provided at the well head, and a quantity of gas or air under pressure admitted suddenly into the well head, will, after a sufficient lapse of time, cause a perceptible puff of air or gas at the outlet. The elapsed time from the instant of admitting the gas or air under pressure until the occurrence of the puff at the outlet, will be the time consumed for the impulse wave to travel down and return from the bottom of the well. Such an impulse wave travels at the same velocity as sound, and if the elapsed time has been observed, it is possible, by employing a simple formula, to compute the depth of the well.

Referring more particularly to the parts and especially to Figure 1, 1 indicates a reservoir for any gas, for example, air, under considerable pressure, and this reservoir is connected through a suitable connection 2 with the valves 3, to an impulse chamber 4, being provided with a gauge 5 for indicating its internal pressure. The other end of this impulse chamber is connected through a quick opening valve or cock 6 to the well head or casing head 7. A flow pipe 8 may extend up through this casing head.

At any point on the periphery of the casing head an outlet 9 is provided to the atmosphere. The valve 6 may be mounted in a pipe connection 10 which can be readily connected to the side of the casing.

In using the apparatus, the valve 6 should be closed and the valves 3 opened to permit a quantity of the compressed air or gas to accumulate in the impulse chamber 4, for example, at a pressure of one hundred pounds per square inch. The valves 3 would then be closed.

In making the test for determining the well depth, the valve 6 would be suddenly opened, thereby permitting a quantity of the compressed air or gas in the chamber to flow into the well head. This will produce an impulse wave which would pass downwardly as indicated by the arrows at the left side of the casing and this wave would eventually impinge upon the surface 11 at the well bottom 12 and would be reflected back toward the head of the well. When the impulse wave, after its reflection by the surface 11, arrives at the well head, a perceptible puff of the air or gas will occur at the outlet 9. This puff can be felt readily simply by holding one's hand in front of the outlet. At the instant that the valve 6 is opened a stop watch is started, and at the instant that the puff is felt at the outlet 9, the stop watch is stopped. The elapsed time will be the time required for the impulse wave to traverse the space from the local point at the well head to the surface 11, and return.

The velocity of this impulse wave will be substantially the same as that of a sound wave and can be computed by the following formula:

$$\text{Velocity} = \sqrt{\frac{Cp}{Cv} \times \frac{P}{D}}$$

In this formula Cp equals the specific heat of the gas or air at constant pressure and Cv equals the specific heat of the gas or air at constant volume. The pressure P is usually expressed in pounds per square ft., and the density D of the gas would be expressed in pounds mass per cubic ft. This will express the velocity in feet per second.

From this formula it is evident that the velocity of the impulse wave is independent of the pressure, for the reason that when the pressure is increased the density is also increased in the same proportion. If very accurate results are necessary, correction for temperature changes may be made according to well-known formulas.

If it is desired to have the result of the test indicated or recorded, this can be accomplished by providing a small pipe connection 13 (see Figure 2) which is attached to the casing 14 instead of the outlet 9, and this connection may carry a microphone 15 which is electrically connected with an indicating or recording instrument 16. If desired, the circuit connection 17 between the microphone and the indicator or recorder 16 may include an amplifier 18 connected to conductors 19 and 20 of an electric power circuit.

The recorder 16 illustrated may be provided with a pen arm 21 which would be controlled by an impulse in the circuit 17, and this pen arm would carry a pen or pencil 22 to run on the face of a recording drum 23 mounted to rotate on its horizontal axis in bearings 24.

This recording drum would be rotated at a uniform speed when the test was started, and the pen 22 would run in a straight line 25 on the drum and produce a laterally disposed peak in the line when the test started, and when the test ended by the return of the impulse wave from the bottom of the well. The test would be made in the same manner as that described in connection with Figure 1, and the apparatus used would be the same as illustrated at the left side of Figure 2.

If the well is under pressure, the invention can be practiced without the use of a high pressure gas, by merely permitting the quick exit of some of the gas in the well. This is illustrated in Figure 3 in which 26 indicates the well head which is provided at one side with a connection 27 carrying a quick opening valve or cock 28. The casing is provided with a pipe connection 29 carrying a microphone 30 with circuit wires 31 and 32 connecting it up to an amplifier and recording instrument. In practicing the invention, as illustrated in Figure 3, the sudden exit of a small quantity of gas under pressure from the interior of the head will cause an impulse wave to start from the well head, and thence to the liquid at the bottom of the well; this impulse will return, and the instant of arrival of this impulse wave at the well head 26 will be indicated by the microphone. The microphone and its connected indicating and recording instrument would also indicate the instant at which the valve 28 was open, thereby indicating the elapsed time. Hence, in using the formula in this case, also, it will be necessary to bear in mind that the impulse wave travels twice through the length or depth of the well.

In using the term "gas" in this specification and claims, it should be understood that the term, when used in its broad sense, is intended to include air which is, in fact, a gas.

It is understood that the embodiment of the invention described herein, is only one of the many embodiments this invention may take, and we do not wish to be limited in the practice of the invention, nor in the claims, to the particular embodiment set forth.

It is evident that our invention can be practiced also when the casing has atmospheric pres-

sure within it or a partial vacuum, and with the same facility as when the well is under a high pressure.

What we claim is:—

1. A method of measuring the depth of a well having a casing head and casing, which consists in maintaining a confined supply of gas under pressure at the well head on the exterior of the casing, suddenly admitting a quantity of the said gas under pressure into the casing head and thereby producing a substantial change in static pressure and an impulse wave in the gas or air within the casing, and observing the elapsed time for the impulse wave to traverse the space from the casing head to the bottom of the well and back again to the casing head.

2. A method of measuring the depth of a well having a casing head and casing, which consists in confining a quantity of gas under pressure in the casing head, suddenly liberating a quantity of said gas and thereby suddenly reducing the static pressure in the casing head and producing an impulse wave in the gas within the casing, and observing the elapsed time for the impulse wave to traverse the space from the casing head to the well bottom and back to the casing head.

3. In apparatus for measuring the depth of a well, the combination of an impulse chamber carrying a gas maintained under pressure, a connection from the impulse chamber to the head of the well including a quick opening valve, said well having an outlet to the atmosphere, said parts cooperating so that when the valve is suddenly opened, a portion of the gas under pressure will pass into the well and thereby raise the static pressure of the gas at the head of the well to produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, said impulse wave operating to produce a puff of gas at said outlet when the impulse wave arrives at the well head, thereby enabling the elapsed time during the wave's travel, to be observed.

4. In apparatus for measuring the depth of a well, the combination of an impulse chamber carrying a gas under pressure at the earth's surface, a connection from the impulse chamber to the head of the well including a quick opening valve, said well having an outlet to the atmosphere, said parts cooperating so that when the valve is suddenly opened, a portion of the gas under pressure will pass into the well and thereby cause an increase of static pressure in the gas in the well head, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, and means for indicating the elapsed time for the wave to traverse the space to the well bottom and return.

5. In apparatus for measuring the depth of a closed well, the combination of an impulse chamber carrying a gas under pressure at the earth's surface, a connection from the impulse chamber to the head of the well including a quick opening valve, said parts cooperating so that when the valve is suddenly opened, a portion of the gas under pressure will pass into the well and thereby cause a rise in the static pressure in the well head, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, and means connected with the well for indicating the elapsed time for the wave to traverse the space to the well bottom and return to the surface.

6. In apparatus for measuring the depth of a closed well, the combination of an impulse chamber carrying a gas under pressure, a connection from the impulse chamber to the interior of the well including a quick opening valve, said parts cooperating so that when the valve is suddenly opened, a portion of the gas under pressure will pass into the well and thereby cause a rise in the well head static pressure, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, and a microphone connected with the well for indicating the instant the wave completes its travel within the well.

7. In apparatus for measuring the depth of a closed well, the combination of an impulse chamber carrying a gas under pressure, a connection from the impulse chamber to the interior of the well including a quick opening valve, said parts cooperating so that when the valve is suddenly opened, a portion of the gas under pressure will pass into the well and thereby raise the static pressure in the well head, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, a microphone connected with the well, and a recording device electrically connected with the microphone.

8. In apparatus for measuring the depth of a closed well, the combination of an impulse chamber carrying a gas under pressure, a connection from the impulse chamber to the interior of the well including a quick opening valve, said parts cooperating so that when the valve is suddenly opened, a portion of the gas under pressure will pass into the well and thereby raise the static pressure in the well head, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, a microphone connected with the well, an indicating device electrically connected with the microphone, and an amplifier between the microphone and the indicating device cooperating to indicate the elapsed time for the wave to traverse the space to the well bottom.

9. A method of measuring the distance to an obstruction or liquid in a well, which consists in maintaining a confined supply of gas under pressure at the well's mouth, suddenly liberating a quantity of the said gas under pressure at the well mouth and thereby producing a substantial change in static pressure and an impulse wave in the gas in the well, and observing the elapsed time for the impulse wave to traverse the space from the head of the well to the obstruction, and back again to the well's mouth.

HAROLD T. WYATT.
PAUL E. LEHR.

DEFENDANT'S EXHIBIT O-13

Scott Patent No. 2,173,426

[Endorsed]: Filed Nov. 4, 1942.

1108

Sept. 19, 1939. H. H. SCOTT 2,173,426

ELECTRIC SYSTEM

Filed Aug. 30, 1937 7 Sheets-Sheet 1

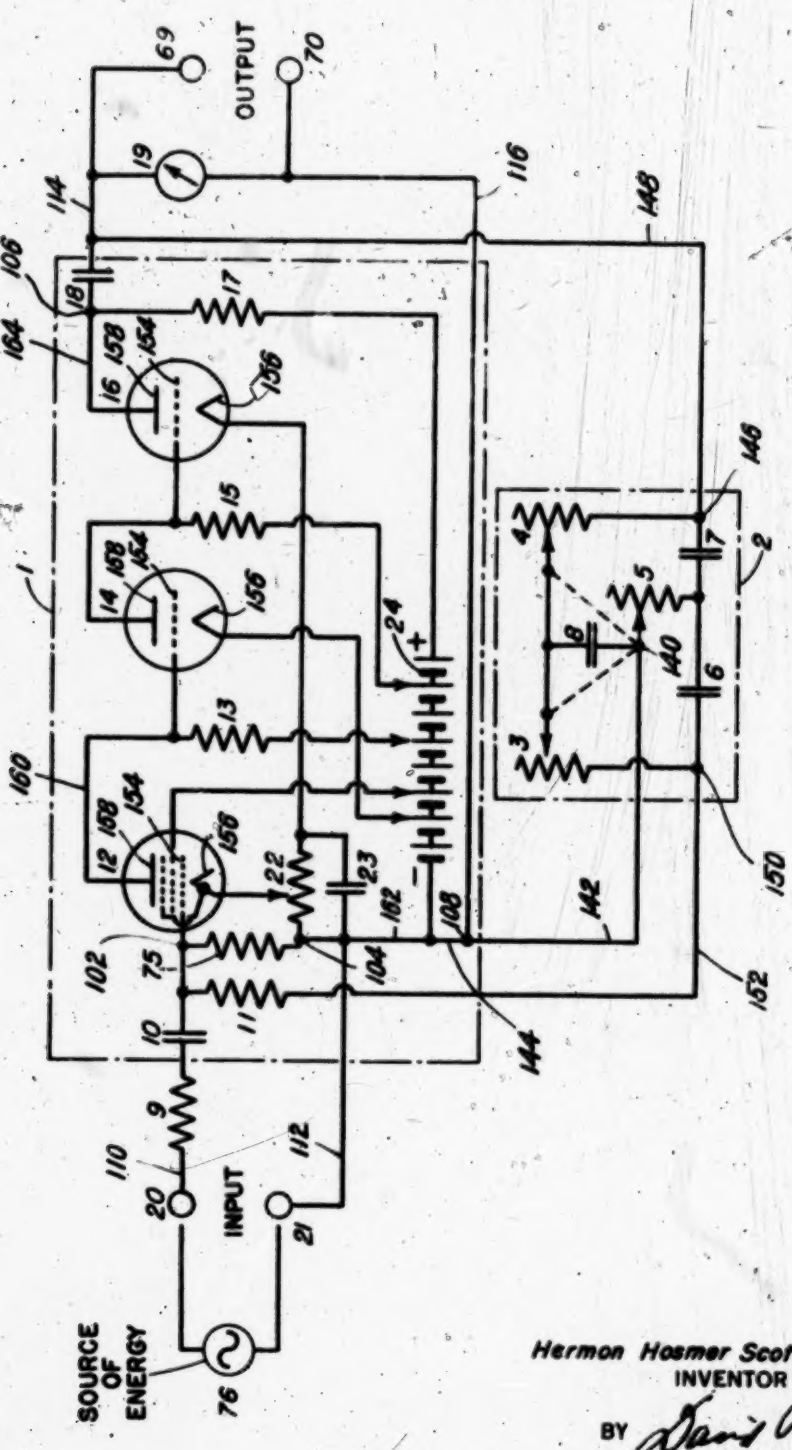


Fig.1

Hermon Hosmer Scott
INVENTOR

BY Davis Rines

ATTORNEY

4110

Sept. 19, 1939. H. H. SCOTT 2,173,426

ELECTRIC SYSTEM

Filed Aug. 30, 1937 7 Sheets-Sheet 2

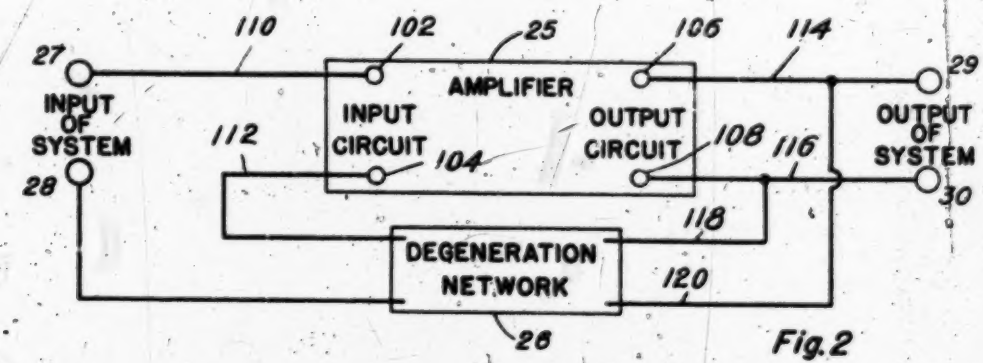


Fig. 2

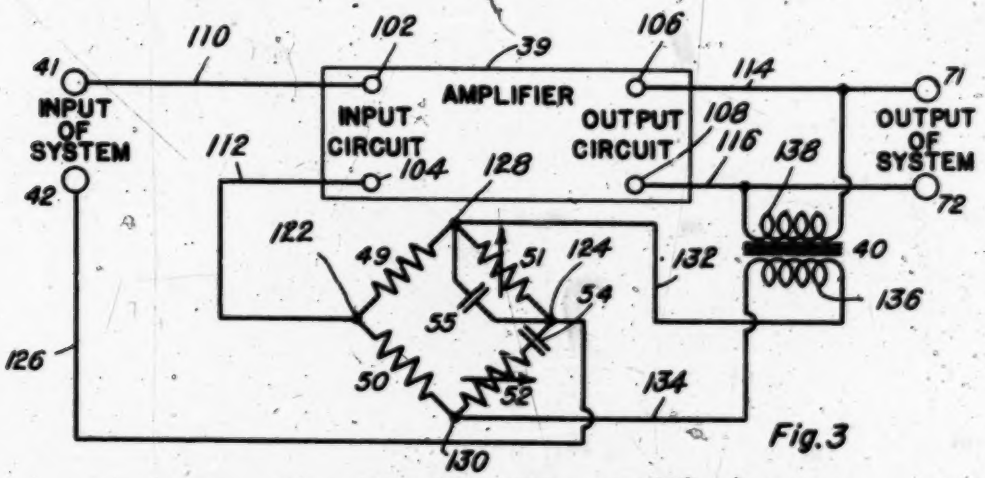


Fig. 3

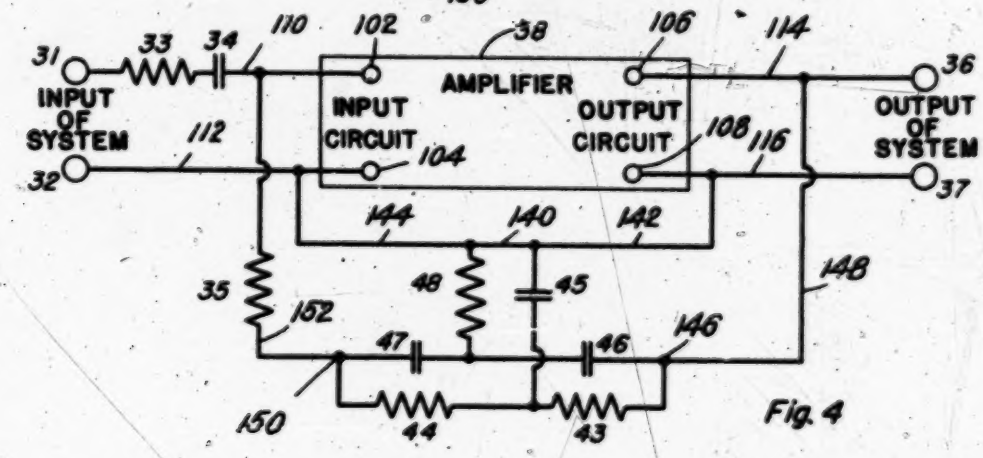


Fig. 4

Hermon Hosmer Scott
INVENTOR

BY David Rines

ATTORNEY

1112

Sept. 19, 1939. H. H. SCOTT 2,173,426

ELECTRIC SYSTEM

Filed Aug. 30, 1937 7 Sheets-Sheet 3

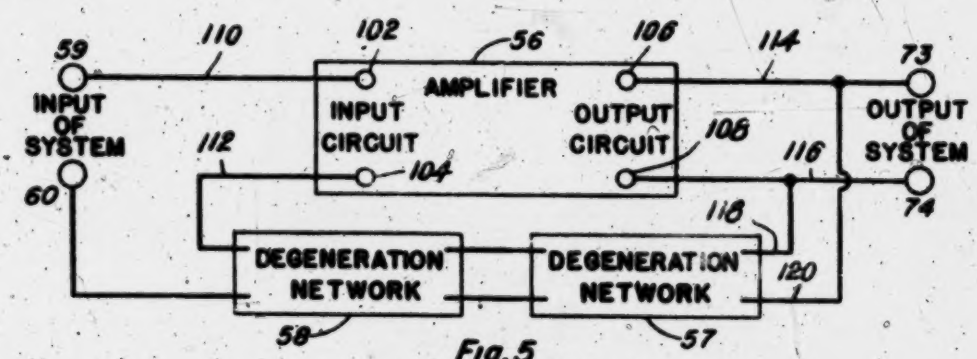


Fig. 5

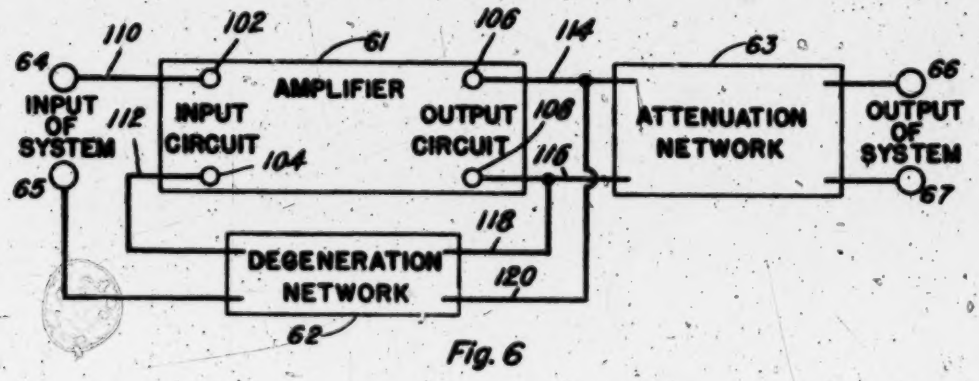


Fig. 6

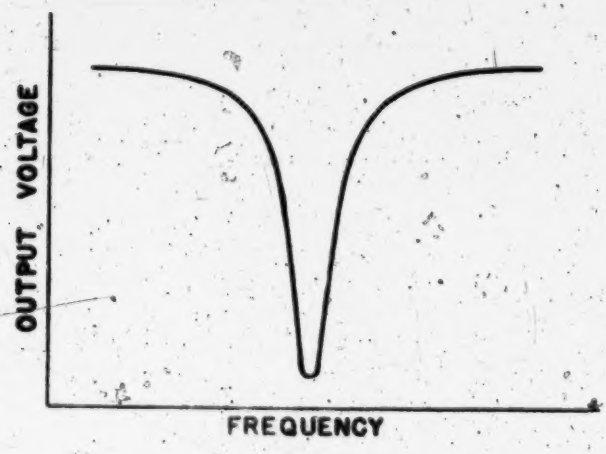


Fig. 7

Hermon Hosmer Scott
INVENTOR

BY David Rines

ATTORNEY

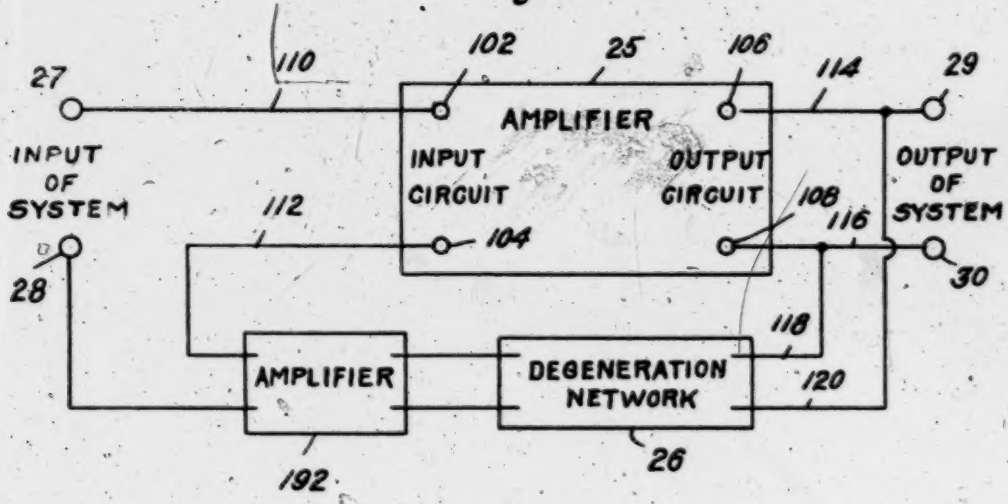
1114

Sept. 19, 1939. H. H. SCOTT 2,173,426

ELECTRIC SYSTEM

Filed Aug. 30, 1937 7 Sheets-Sheet 4

Fig. 13.



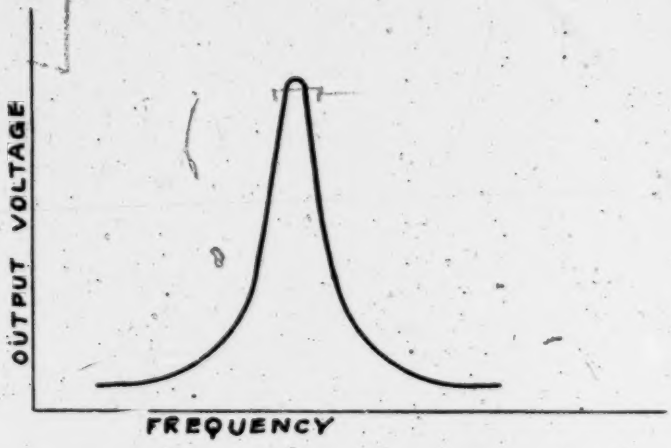


Fig. 8.

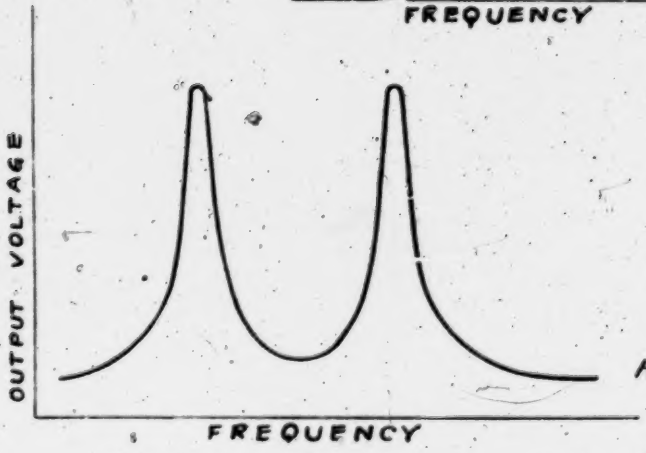


Fig. 9.

Hermon Hosmer Scott.
INVENTOR
BY David Rines
ATTORNEY

1416

Sept. 19, 1939. H. H. SCOTT 2,173,426

ELECTRIC SYSTEM

Filed Aug. 30, 1937 7 Sheets-Sheet 5

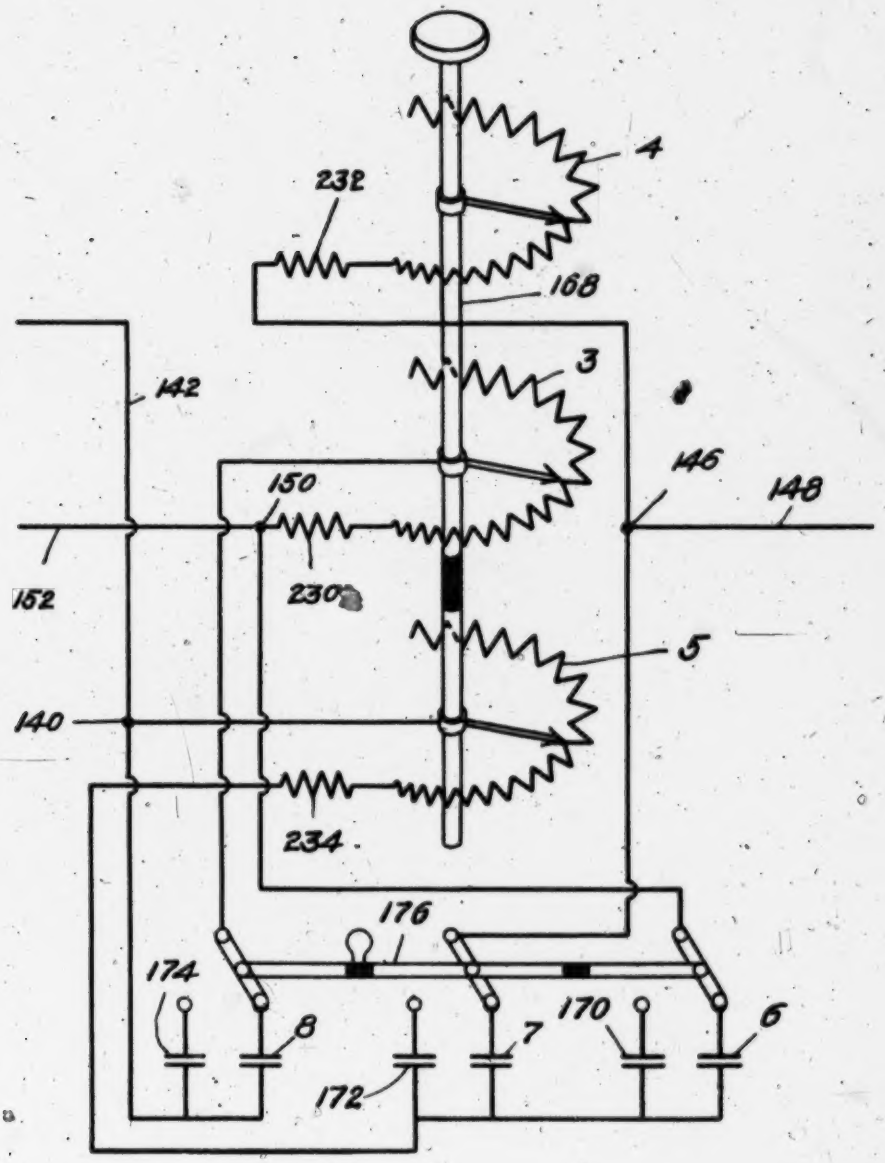


Fig. 10.

HERMON HOSMER SCOTT

INVENTOR

BY David Rines

ATTORNEY

1118

Sept. 19, 1939. H. H. SCOTT 2,173,426

ELECTRIC SYSTEM

Filed Aug. 30, 1937 7 Sheets-Sheet 6

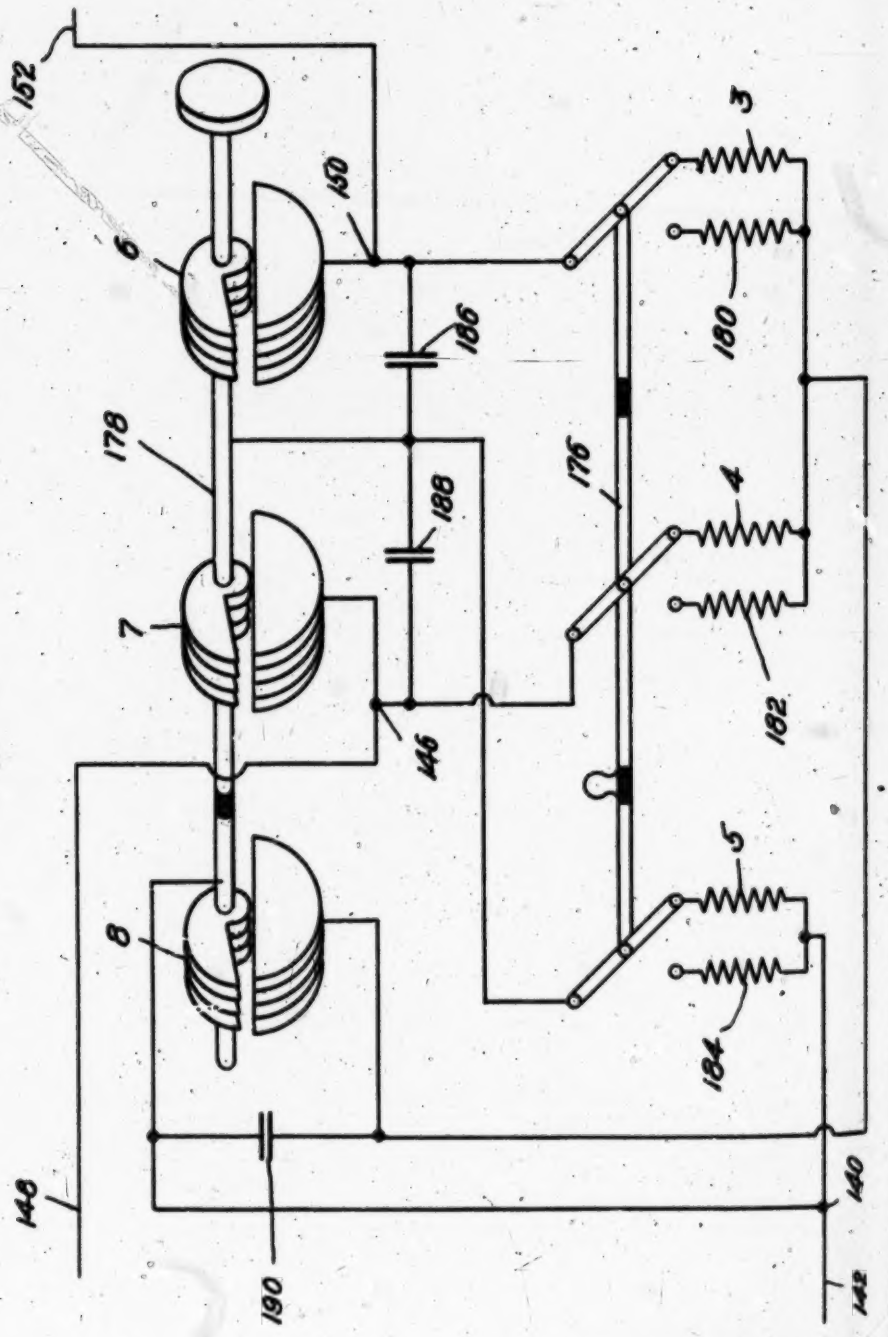


Fig. 11.

Herman Hosmer Scott.
INVENTOR

BY David Rines

ATTORNEY

1120

Sept. 19, 1939. H. H. SCOTT 2,173,426

ELECTRIC SYSTEM

Filed Aug. 30, 1937 7 Sheets-Sheet 7

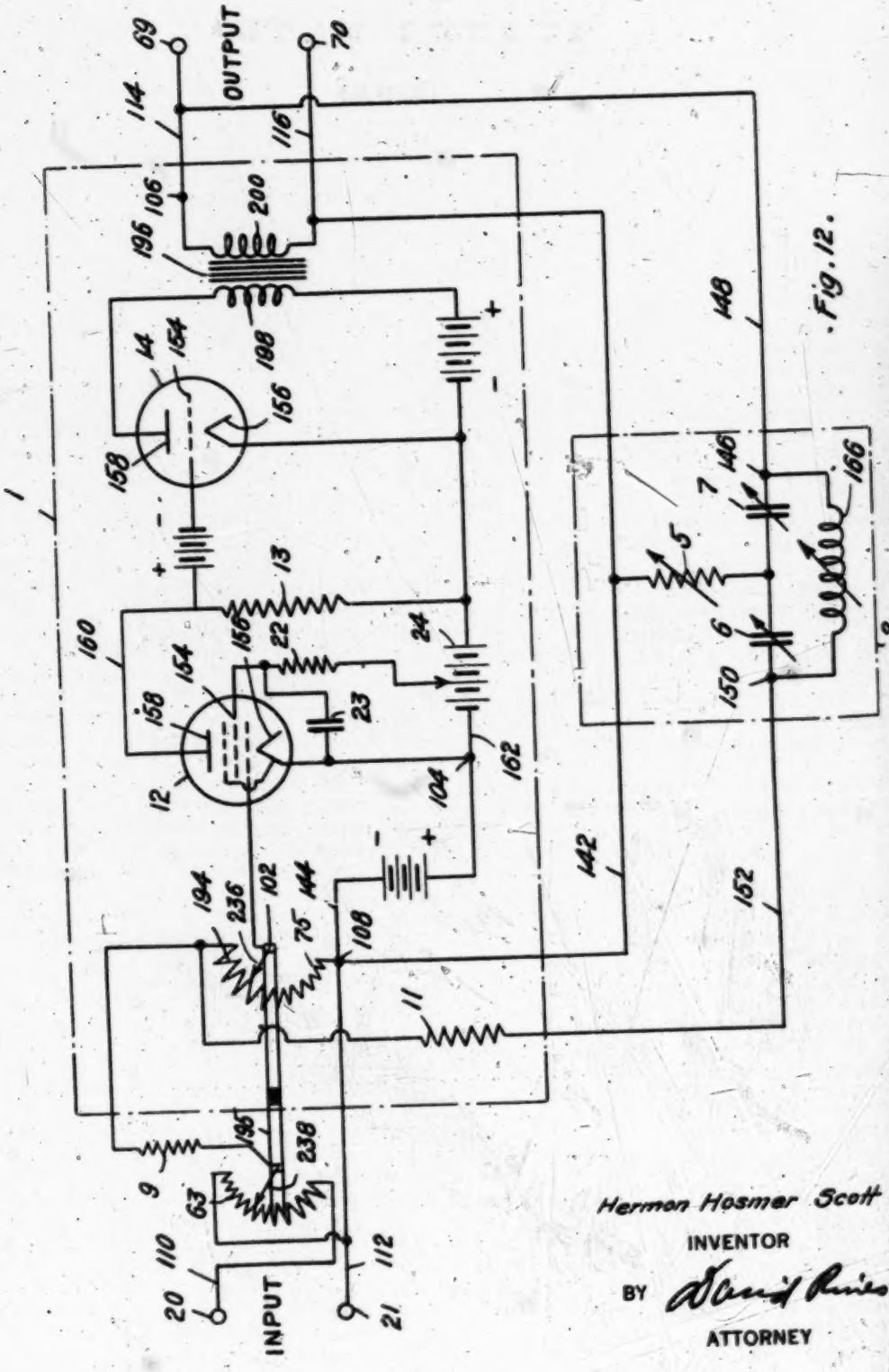


Fig. 12.

Hermon Hosmer Scott

INVENTOR

BY David Rines

ATTORNEY

Patented Sept. 19, 1939 2,173,426

UNITED STATES PATENT OFFICE

2,173,426

ELECTRIC SYSTEM

Hermon Hosmer Scott, Somerville, Mass., assignor to General Radio Company, Cambridge, Mass., a corporation of Massachusetts

Application August 30, 1937, Serial No. 161,831

50 Claims. (Cl. 178—44)

The present invention relates to electric systems, and more particularly to systems for selecting predetermined frequencies from currents or voltages containing a number of different frequencies.

An electric system may transmit or amplify either a single frequency, or a band of frequencies, eliminating or attenuating other frequencies. A single frequency to which an electric system is selective may be regarded as that frequency which the system transmits at substantially maximum amplitude. In the case of a band of frequencies to which the system is selective, that band may be regarded as including those frequencies which are transmitted at a level not less than a predetermined value, say, three decibels, below the maximum transmission in that band.

Various devices are in use or have been proposed for obtaining an electrical circuit which is selective with regard to frequency. The tuned circuits used in radio receivers, and conventional types of filters employing inductances and condensers are examples of widely-used types of selective circuits. Such devices are satisfactory at higher frequencies, but as the frequency is lowered the size of the inductances and condensers becomes increasingly larger. In particular, the inductances for low frequencies are frequently cumbersome and expensive and, because of the large amount of wire with which they must be wound, the resistance is so high as often to make it difficult or even impossible to obtain a satisfactory degree of selectivity.

Further, the use of iron cores in the inductances often results in harmonic distortion and many common types of inductances are subject to magnetic interference; that is, the presence of alternating magnetic fields generated by other electrical equipment will cause interfering voltages to be picked up by the inductances in the filter or tuned circuit, thus causing undesired signals to be present in the output.

A further difficulty is encountered in those cases where it is desired to vary the frequency response or pass band over wide ranges of frequency. Since the problem of varying either inductances or condensers becomes increasingly serious as their size increases, in many variable filter systems only the inductances or the condensers are varied. Such an arrangement is generally satisfactory over a relatively small change in frequency, but for large percentage changes this results in serious impedance shifts and variations in sensitivity.

One common use for sharply-selective circuits is in the analysis of complicated electrical waves, the selective circuits being tuned successively to each of the component frequencies of the wave in order to obtain an individual evaluation of each component. To fix the ideas, an analyzer may be considered to comprise a combination of a selective circuit and some form of indicator for indicating the output or the transmission of said selective circuit. Conventional tuned circuits using inductances and condensers have been used for this purpose, but they are generally bulky, expensive and subject to magnetic interference. A more common method is the heterodyne-type analyzer in which the wave to be measured is heterodyned with a practically sinusoidal wave-form obtained from a vacuum-tube oscillator or other similar source in order to produce a resulting beat note which can be passed through a fixed filter. The frequency to which a system of this type is selective is determined by the frequency of the sinusoidal wave-form with which the unknown wave-form is heterodyned, while the filter circuits themselves remain fixed. One serious disadvantage of this arrangement is that, regardless of the frequency to which the system responds, the band width or selectivity curve has the same width in cycles per second. This often results in unusually sharp selectivity at high frequencies, and broad selectivity at low frequencies.

Selective circuits incorporating resistances and condensers but no inductances have been proposed and used for a few special applications, but the usual circuit of this type does not have as sharp selectivity as is generally desired and also causes a large loss in transmission even at those frequencies where the transmission is greatest.

One of the objects of the present invention is to provide a selective electrical circuit, the response of which may be varied over wide frequency ranges without complicated tuning and switching mechanisms and without any serious shifts in the input and output impedances of the system or its sensitivity. One of the important features of the invention is that this result may be obtained without necessitating the use of any inductances whatsoever, using a frequency-determining system which may consist of resistances and condensers only. The frequency to which such a system is selective can, accordingly, be varied by merely varying resistances or condensers, or both resistances and condensers.

Another object of the present invention is to provide a selective circuit, the selectivity curve

of which is a percentage function of frequency. Such a device is particularly valuable in many types of sound-analysis work where the wave-form being analyzed is obtained from a microphone and amplifier and represents the wave-form of the sound which it is desired to analyze.

Another object of this invention is to provide a selective circuit, the selectivity or band width of which may be varied without changing any of the frequency-determining elements.

A further object is to provide a novel selective amplifier.

Still another object of the invention is to provide a novel wave filter.

Still another object of the invention, furthermore, is to provide a new and improved wave or hamonic analyzer.

Inverse feed-back or degenerative systems are now in use in order to obtain a substantially equal frequency response over wide frequency ranges. A characteristic of such systems is that the over-all amplification or sensitivity is considerably reduced by the introduction of degeneration. A feature of this invention, on the other hand, with the above objects in view, is to employ the inverse feed-back principle, not to obtain equal response over a wide range of frequency, but rather to obtain a response which is sharply selective with regard to frequency. An important feature of this type of inverse feed-back system is that the desirable characteristics are obtained without appreciable loss of sensitivity or amplification, that is, the sensitivity of the system at its point of maximum response may be made the same as without the inverse feed-back arrangement.

Other and further objects will be explained hereinafter and will be particularly pointed out in the accompanying claims.

The invention will now be explained in connection with the accompanying drawings, in which Figure 1 is a diagrammatic and simplified view of circuits and apparatus arranged and constructed according to a preferred embodiment of the present invention; Figure 2 is a further simplified diagrammatic view illustrating a principle underlying the invention; Figure 3 is a view similar to Figure 2, illustrating one form of degeneration network; Figure 4 is a similar view illustrating another form of degeneration network; Figures 5 and 6 are views similar to Figure 2 of modifications; Figure 7 is a diagram illustrating a response curve that is representative of many prior-art types of networks, including the hereinafter described degenerative network; Figure 8 is a similar diagram illustrating a response curve in accordance with the present invention; Figure 9 is a diagram similar to Figure 8 illustrating a modified response curve; and Figures 10 to 13 are views of further modifications.

The response curve shown in Fig. 7, showing the relation between the output voltage and the frequency, is representative of many types of networks, including some combinations of resistance, capacitance and inductance, or mechanical, piezo-electric or magnetostriction devices. The characteristic feature of a curve of this type is that a single frequency or band of frequencies is cancelled out practically entirely, while a reasonable degree of transmission is obtained at other frequencies. In other words, such a device is a form of band-elimination filter.

Such a characteristic can be obtained in a network using only resistances and capacitors such as, for instance, the Wheatstone bridge, including the Wien bridge, and a double-T or parallel-T network. The Wien bridge, for example, illustrated in Fig. 3, is provided with resistors 49, 50, 51 and 52 in its respective arms, and capacitances 54 and 55 respectively in series with and in shunt to the respective resistors 52 and 51. The resistors 49 and 50 are preferably fixed and the resistors 51 and 52 are variable. The parallel-T network consists, as its name implies, of two T networks connected in parallel, as illustrated in Figs. 1 and 4. In Fig. 1, the network includes the circuit elements in the broken line marked 2. It is illustrated as comprising only resistances 3, 4 and 5 (Fig. 1) or 43, 44 and 45 (Fig. 4) and condensers 6, 7 and 8 (Fig. 1) or 46, 46 and 47 (Fig. 4), since this is a convenient form of such a network, but inductances may also be included if desired. The particular T network shown in Figs. 1 and 4 has certain desirable characteristics which will be discussed later.

A bridged-T network may comprise only a single T network as, for instance, the circuit elements 5, 6 and 7 of Fig. 1, or 45, 47 and 48 of Fig. 4, but with another impedance connected directly in shunt with the two series arms 6 and 7 or 46 and 47, respectively. This is illustrated in Fig. 12, the impedance connected between the opposite terminals of capacitances 6 and 7 being represented by the coil 108. It will be understood that the bridge-T, like the parallel-T, network is not restricted to resistors and capacitors. The elements of both networks may comprise any combination of impedances, including inductors.

The desired characteristics for a selective circuit in accordance with the present invention, as previously outlined, may be practically the inverse of that shown in Fig. 7; that is, the circuit should respond to a single frequency or a narrow band of frequencies and should attenuate or eliminate frequencies outside of this range, so as to yield a response curve somewhat of the character illustrated in Fig. 8.

In accordance with a principle of this invention, therefore, a circuit having the characteristic shown in Fig. 7 may be combined with suitable auxiliary apparatus so that the net over-all characteristic shall be as shown in Fig. 8. The inverse of the usual characteristic of the curve is thus obtained, a band-suppression network being employed to produce a band-pass system.

This may be effected in any desired way, as, for example, is diagrammatically illustrated in Fig. 2. The amplifier 25 there diagrammatically illustrated my be of ny desired type, providing an amount of gain, the importance of which will be discussed hereinafter. The amplifier is designated in other figures by other numerals: 1 in Fig. 1, 39 in Fig. 3, 38 in Fig. 4, 86 in Fig. 5 and 91 in Fig. 6. It is shown provided with input terminals 102 and 104, connected to its input circuit, and output terminals 106 and 108, connected to its output circuit. The input terminals 102 and 104 may be connected by conductors 110 and 112 to a source of energy through the medium of terminals 27 and 28, which constitute the input terminals of the system. Such a source of energy is shown in Fig. 1 at 76 but is omitted from Fig. 2 and other figures, for clearness. In other figures, the terminals 27, 28 are represented by other numerals, as 28, 21 (Fig. 1), 41, 42 (Fig. 3), 51, 52 (Fig. 4), 89, 90 (Fig. 5), and 94,

(Fig. 6). In Fig. 2, the terminals 102 and 27 e shown directly connected together by the nductor 110, and the terminal 104 is shown nnected by the conductor 112 to the terminal indirectly, in series with a degenerative net- ork 26, as hereinafter more fully described. It ill be understood, however, that the terminals 4 and 28 may be directly connected together by e conductor 112, as illustrated in Fig. 4, and at other elements may be inserted in the con- uctors 110 and 112, such as the resistor 32 and e condenser 34 of Fig. 4. The terminals 106 and 8 may similarly be connected by conductors 114 nd 116 to any desired load through the medium f terminals 29 and 30, which thus constitute the utput terminals of the system. These output rminals are represented in Fig. 1 as 69, 70, in ig. 3 as 71, 72, in Fig. 4 as 36, 37, in Fig. 5 s 73, 74 and in Fig. 6 as 66, 67.

The said degenerative network 26 is connected etween the input terminals 27 and 28 and the utput terminals 29 and 30 of the system so as o feed back energy from the output circuit of he amplifier to its input circuit. To this end, he input of the feed-back network 26 is shown onnected by conductors 118 and 120 to the out- ut circuit of the amplifier 25, and the output of he network is connected to the input circuit of he amplifier. By thus feeding the input of the etwork back to the input circuit of the amplifier, he net voltage on the input circuit of the ampli- fier is constituted of the combination of the volt- age applied from the voltage source to the termi- nals 27 and 28 and the voltage obtained from the degenerative network 26.

In accordance with the present invention, therefore, selectivity is obtained with the aid of a resistance-capacitance network, but without introducing loss in the normal transmission of the system at the frequencies of maximum trans- mission.

The transmission characteristics of the feed- back network 26 are similar to those shown in Fig. 7, so as to provide maximum attenuation or zero transmission or coupling at that frequency or frequencies where it is desired that the sys- tem as a whole shall provide maximum trans- mission. At other frequencies, which the ampli- fier would normally pass, the network provides a certain amount of transmission and the voltage obtained from the network is fed back to the amplifier input, so that it has a phase difference between 90 and 270 degrees with respect to the voltage applied to terminals 27 and 28. Accord- ingly, as the voltage obtained from the feed-back network increases, it tends to cancel out the net voltage applied to the amplifier, thus reducing the effective gain of the amplifier, or, if the feed- back is sufficiently great, practically eliminating the gain entirely. At the frequency or frequen- cies where the degenerative network provides zero or very low transmission or coupling, the net ef- fective gain of the amplifier is at its maximum or near its maximum, respectively. The result is that the transmission characteristic of the sys- tem as a whole between the input terminals 27 and 28 and the output terminals 29 and 30 has a general characteristic as shown in Fig. 8. It will be seen that the difference in transmission of the system between the frequencies of maximum and minimum transmission, which characteristic may be defined as the maximum suppression of the system, depends upon both the gain of the ampli- fier and the transmission characteristics of the degeneration network. The effect of shifting the amplifier gain is to change appreciably the trans- mission at those frequencies where the transmis- sion is greatest with only a comparatively minor change in the transmission where it is at a mini- mum, thus modifying the selectivity curve and changing the maximum suppression.

It is evident that there are many combinations of apparatus and circuits which will produce this result. The amplifier, for instance, may be one of the more conventional vacuum-tube types em- ploying transformers, resistances, condensers, and, if desired, inductances or transformers as coupling units, or the amplifier may be of some electro-mechanical or other type. The feed-back circuit, also, may be one of many arrangements which will provide the desired characteristics. Since there are a great number of filter and bridge circuits which provide zero or very low transmis- sion at a single frequency or over a band of fre- quencies, it is obvious that the invention covers a large number of possible circuit arrangements. Figs. 3 and 4 show two systems employing common types of resistance-capacitance networks for the inverse feed-back system. In Fig. 3, the inverse feed-back system is illustrated as comprising the before-mentioned Wien bridge. Circuits of this type are widely used for measuring frequency, in which application the suppression of a single frequency or narrow band of frequencies is im- portant. In this use of the Wien bridge, how- ever, the combination with the amplifier and as- sociated apparatus provides an over-all response characteristic which is at a maximum at that frequency to which the bridge is balanced. In a circuit of this type, the response characteristics are determined by the relative values of the re- sistances and the condensers. The characteris- tics of the network may be varied by varying all or some of these components.

As illustrated in Fig. 3, the two opposite ver- tices 122 and 124 of the bridge may be respec- tively connected to the conductor 112 and a con- ductor 126 leading to the input terminal 42. The output circuit of the Wien bridge is thus connected to the input circuit of the amplifier. The vertices 122 and 124 may, however, be di- rectly connected to the conductors 112 and 110, as suggested in Fig. 4. The other two opposite vertices 128 and 130 are shown respectively con- nected by conductors 132 and 134 to the sec- ondary winding 136 of a transformer 40 the pri- mary winding 138 of which is connected by the conductors 114 and 116 to the amplifier output terminals 106 and 108. The output circuit of the amplifier is thus connected to the input circuit of the Wien bridge.

The coupling of the degenerative coupling means is substantially zero at the predetermined single frequency in question, as is true with all networks having an exact null or zero at balance. The coupling transformer 40 merely provides the proper balanced-to-ground circuits for the bridge. It is obvious that transformer 40 could be con- nected between the bridge and the input circuit of the amplifier as well as in the position shown in the diagram. The primary winding 138 of the transformer 40, for example, may be connected to the vertices 122 and 124 of the bridge and the secondary winding 136 to the conductors 112 and 126, the vertices 128 and 130 of the bridge being then directly connected to the conductors 114 and 116.

Fig. 4 represents an improvement over the cir- cuit shown in Fig. 3 in that no transformer 40 is used, since the degeneration network 26 consists

of a three-terminal network having one terminal 148 common to both its input and its output circuits. The terminal 148 is shown connected by a conductor 142 to the terminal 108 and by a conductor 144 to the terminal 104. One of the other two terminals of the network is shown at 146, connected by a conductor 148 to the terminal 106. The third terminal of the network is shown at 150, connected by a conductor 152, through a resistor 38, to the terminal 102. The particular three-terminal network shown is the previously described double-T network, having a characteristic similar to the Wien bridge of Fig. 3, and the frequency of zero transmission may be varied by shifting the resistances 43, 44 and 45, or the condensers 46, 46 and 47, or all six components. It will be noted that in this diagram the feed-back voltage is fed into the amplifier 36 in parallel with the voltage from the source 76 applied to the input terminals 31 and 32. The network consisting of resistances 33 and 35 and condenser 34 is so arranged that neither the feed-back network nor any equipment connected to terminals 31 and 32 has any appreciable effect upon the characteristics of the other. In general an input system of this type provides somewhat less over-all sensitivity than that shown in Fig. 3, but has the important advantage that the input of the system as a whole has one terminal 148 in common with the input of the amplifier.

The two methods of introducing the degeneration voltage into the amplifier, as shown in Figs. 3 and 4, are, of course, interchangeable. Either the series or the parallel arrangement may be used. Any choice between these systems will generally depend upon consideration of the particular application of the invention and, in general, upon the type of circuit or source of energy to be connected to the input of the system. It is also understood that more elaborate arrangements for coupling the feed-back circuit to the amplifier may be used, and they may consist of transformers, additional amplifying stages, etc.

There are several advantages of a system of this type which should be noted. In the first place, if the inverse-feed-back network provides complete suppression at a certain frequency, the amplifier gain is normal at that frequency and not affected by the network. Accordingly, if an adjustable network is used so that its zero transmission frequency is adjustable and if the network is so designed and constructed that practically complete suppression is obtained at any frequency to which it is adjusted, the sensitivity of the amplifier to that frequency will be the same as the sensitivity of the amplifier to the same frequency when the network is not used. It is, accordingly, a relatively simple matter to obtain practically constant sensitivity over a wide frequency range by merely using an amplifier with practically constant gain over that range and a feed-back network which gives practically complete suppression at the passed frequency. Of course, if the amplifier characteristic is not flat over a wide range, or if the feed-back network does not give complete suppression, one of these characteristics may be made to balance the other. It should also be noted that since the feed-back network operates directly into a grid circuit, as illustrated in Fig. 1, or into a high-impedance circuit, and may consist itself of high impedances, no appreciable amount of power need be drawn from the amplifier output by the feed-back system.

It should also be noted that since the feed-back network provides suppression at the frequencies which the system transmits as a whole, it is a simple matter to include several similar networks but tuned or balanced to different frequencies in order to obtain two or more pass bands. Fig. 5 shows an arrangement of this sort consisting of amplifier 56 and two feed-back networks 57 and 58, one operating into the other. Since the combination of these two networks may be made to suppress two frequencies or two bands of frequencies, a characteristic is obtained of the general character shown in Fig. 9. Obviously, other networks may be added to the system to provide other pass bands. It is also, of course, possible to combine the several networks into a single network which will provide the same net results.

According to the preferred embodiment of the invention illustrated in Fig. 1, the amplifier is of the three-stage direct-coupled type, the stages being represented by vacuum tubes 12, 14 and 16, each comprising a cathode 106, a grid 104 and an anode or plate 108. The input circuit of the amplifier, to which the source 76 is connected, may be traced from the terminal 30, by way of the conductor 110, through the resistor 9 and the condenser 10, to the terminal 102, and thence to the grid 104 of the tube 12; and from the grid 104 to the filament or cathode 106, a resistor 21 and a condenser 23, in parallel, to the terminal 104; and finally by way of the conductor 111, to the terminal 31. A resistor 75 may be connected in parallel to the grid 104 and the filament 106. The tube 12 is provided with an output circuit extending from its plate or anode 108, by way of a conductor 109, and through a resistor 13, to a plate battery 24, and thence, by way of a conductor 102, to the filament 104. The input circuit of the second stage 14 of the amplifier is shown connected across the resistor 13, and its output circuit is provided with a similar resistor 15 across which the input circuit of the third stage 16 is connected. The output circuit of the amplifier extends from the plate or anode 108 of the tube 16, by way of a conductor 104, to the terminal 106; and through a resistor 17 to the battery 24, and the terminal 108. Each grid 104 of each tube except the first is galvanically or directly connected to the anode of the preceding tube.

The connection from the cathode 106 of the tube 12 to the resistor 22 is shown as variable, thus to render it possible to vary the gain of the amplifier, thus to adjust the width of the band of frequencies to which the system is selective. The same result may be arrived at by varying the potentiometer 194 of Fig. 12.

An amplifier of this type is not necessary, but the particular arrangement shown is used since the phase shift at low frequencies between the grid 104 of the first tube 12 and the plate 108 of the last tube 16 is always between 180 and 270 degrees. This simplifies the design of the feed-back circuit. Any other type of amplifier can also be used, however, it being merely necessary to keep the total phase shift through the amplifier and the feed-back circuit such that a serious amount of regeneration does not take place. That is, for any frequency for which the amplifier gain is greater than the attenuation in the feed-back network the total phase shift should be between 90 and 270 degrees in order to provide proper degeneration. For these reasons, an amplifier comprising an odd number of stages is frequently desirable and the direct-coupling in-

ture prevents undesirable phase shifts, even at very low frequencies.

The amplifier shown is battery-operated at 24, but, obviously, any suitable power-supply equipment could be used. The heaters or filaments 156 of the tubes must, of course, be operated from suitable batteries or transformers.

The components enclosed within the dotted line marked 2 comprise a feed-back circuit of the double-T network type, as shown in Fig. 4. The particular arrangement shows the resistances 3, 4 and 5 variable, and ganged together for operation by a single control, as is illustrated more particularly in Fig. 10. The output of the network 2 is fed back into the amplifier by an arrangement similar to that shown in Fig. 4, by means of the conductors 162 and 163, the resistor 11 of Fig. 1 corresponding to the resistor 35 of Fig. 4. The transmission characteristic of such a system between the input terminals 20, 21 and the output terminals 68, 70 is similar to that of Fig. 4.

For wave-analysis work, a meter or other indicating device 19 may be connected to the output terminals. This indicating device will then show the relative intensity of each component in the wave-form, when resistors 3, 4 and 5 and condensers 6, 7 and 8 are adjusted so that the system is selective to that particular component.

The parallel-T network, including resistances and capacitances only, is shown in the preferred embodiment of the invention of Fig. 1, because this particular type of network is extremely useful at audio frequencies. One condition of balance for such a network is obtained when capacitance 8 equals capacitance 7, each equaling one-half of capacitance 6, when resistance 3 equals resistance 4, each resistance 3 and 4 equaling two times resistance 5, and when the reactance of capacitance 6 is equal in magnitude to resistance 5. This condition of balance for the parallel-T network, as shown in Fig. 1, results in very convenient values for the circuit elements in this network. Obviously, this combination of values lends itself readily to simultaneous operation of the resistances or the condensers by means of a common control. A convenient method for varying such a network over wide ranges at lower frequencies is to employ three variable resistances which are operated by a common control, as illustrated in Fig. 10. By switching various sizes of condensers into the circuit as components 6, 7 and 8, the frequency to which the system is selective may be varied in steps. At higher frequencies, it is sometimes desirable to use variable condensers, which may or may not be connected to a common shaft, and to keep the three resistors fixed, or to vary them in steps by means of a switch. At higher frequencies, a bridged-T network is sometimes more satisfactory than the double-T network on the basis of manufacturing costs and ease of control.

Obviously, the frequency to which this system is selective may be varied by varying the elements in the parallel-T network. A convenient arrangement at lower frequencies is continuously to adjust the three resistances 3, 4 and 5 simultaneously by means of a single control arm 168, and to shift by steps the condensers 6, 7 and 8 or the condensers 170, 172 and 174, respectively, by means of a multi-pole switch 176, as illustrated in Fig. 10. At higher frequencies it may be simpler to use continuously variable condensers 6, 7 and 8 operated by a single control arm 172 and to switch by steps the resistances 3, 4 and 5 or other resistances 180, 182 and 184, respectively, as illustrated in Fig. 11. The condensers 6, 7 and 8 of Fig. 11 are shown bridged by fixed condensers 186, 188 and 190, respectively, for limiting the frequency range. The resistors 230, 232, 234, in series with resistors 3, 4 and 5, respectively, as shown in Fig. 10 are for a similar purpose.

A similar simultaneous adjustment of various of the elements of the Wien-bridge structure of Fig. 3 may be effected as illustrated and described in Letters Patent No. 1,983,447 to Robert F. Field, issued December 4, 1934.

It will be understood that the features illustrated in Figs. 10 and 11 may be embodied in the system of Fig. 1 or other figures, and that the same is true of the other modifications illustrated and described herein. The passive network 26 and the additional amplifier 192 in series therewith illustrated in Fig. 13 may, for example, be embodied in any of the other figures, typified in Fig. 2.

Although the basic circuits shown in Figs. 1, 2, 3, 4 and 5 will provide a certain amount of gain in the pass bands, it is understood that, in some cases, it may be desirable to use such circuits where no gain is necessary or required. Under these conditions it is merely necessary to use the system in conjunction with an attenuator 63, as shown in Fig. 6, which attenuator may be employed to control the sensitivity of the system. The circuit shown includes the amplifier 61, and a feed-back network 62, and functions similarly to the arrangement shown in Fig. 2. By reason of the attenuator 63, however, the over-all amplification or sensitivity may be reduced to any desired value. This attenuator 63, instead of being connected to the output of the system, as shown in Fig. 6, could be connected to the input, as illustrated in Fig. 12. According to the present invention, it is possible to vary the selectivity merely by shifting the gain of the amplifier part of the system without necessitating the changing of any of the frequency- determining elements of the system. This may be effected without changing the over-all sensitivity, if desired, by simultaneously adjusting the attenuator 63 and the potentiometer 194. The potentiometer 194 and the attenuator 63, which are both shown in the input circuit of the first stage, may be actuated simultaneously from a common shaft 196. For constant over-all sensitivity, as previously mentioned, it is obviously necessary to vary the attenuator 63 in such a direction as to tend to decrease the sensitivity when the amplifier gain control 194 is varied in such a direction as to tend to increase the sensitivity, and vice versa.

For the sake of variety, the circuit of Fig. 12 is illustrated as comprising an even number of amplifying stages, respectively, and the phase reversal is illustrated as effected by means of a transformer 198, the primary winding 199 of which is connected in the output circuit of the last amplifier stage, and the secondary winding 200 of which is shown connected to the conductors 114 and 116. By phase reversal, it is intended to denote the before-described shifting of the phase between 90 degrees and 270 degrees.

It will be understood that phase reversals may be effected in other ways also. For example, a coupling may be provided between the output circuit of an even-numbered stage of amplification and the input circuit of a previous even-numbered stage of amplification or between the output of an odd-numbered stage and the input of

a previous odd-numbered stage. If the degeneration network includes a transformer or other means for reversing the phase, the degenerative coupling may be from the output of an even-numbered stage of amplification into the input of an odd-numbered stage, or vice versa.

Other modifications and changes will also occur to persons skilled in the art, and all such are considered to fall within the spirit and scope of the present invention, as defined in the appended claims.

What is claimed is:

1. An electric system having, in combination, a source of energy, a multi-stage amplifier having an input circuit coupled to the source and an output circuit, one of the stages of the amplifier being coupled directly to a previous stage of the amplifier, means for degeneratively coupling the output circuit to the input circuit, and means for rendering the degenerative coupling substantially ineffective at a predetermined frequency or frequencies, the system as a whole having parameters such as to provide substantially maximum transmission at the said predetermined frequency or frequencies in order to render the system as a whole selective at the said predetermined frequency or frequencies and such that at frequencies substantially removed from said predetermined frequency or frequencies substantially the whole output voltage of the amplifier is fed degeneratively through the network back to the input circuit of the amplifier.

2. An electric system having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, and means comprising a network degeneratively coupling non-inductively the output circuit to the input circuit in order to reduce the effective gain of the amplifier, the said network having substantially minimum transmission at a predetermined frequency or frequencies, and the system as a whole having parameters such as to provide substantially maximum transmission at the said predetermined frequency or frequencies in order to render the system as a whole selective at the said predetermined frequency or frequencies and such that at frequencies substantially removed from said predetermined frequency or frequencies substantially the whole output voltage of the amplifier is fed degeneratively through the network back to the input circuit of the amplifier.

3. An electric system having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a plurality of networks for degeneratively coupling the output circuit to the input circuit, the respective networks having substantially minimum transmission characteristics at respective predetermined frequencies, and the system as a whole having parameters such as to provide substantially maximum transmission at the said respective predetermined frequencies in order to render the system as a whole selective to the said respective predetermined frequencies and such that at frequencies substantially removed from said predetermined frequencies a sufficiently large fraction of the output voltage is fed back degeneratively to the input circuit of the amplifier so as to cancel substantially the entire gain of the amplifier.

4. An electric system having, in combination, a source of energy, a direct-current multi-stage amplifier having an input circuit coupled to the source and an output circuit, and means for degeneratively coupling the output circuit to the input circuit in order to reduce the effective gain of the amplifier, the said means having substantially minimum transmission at a predetermined frequency or frequencies, the system as a whole having parameters such as to provide substantially maximum transmission at the said predetermined frequency or frequencies in order to render the system as a whole selective at the said predetermined frequency or frequencies and such that at frequencies substantially removed from said predetermined frequency or frequencies a sufficiently large fraction of the output voltage is fed back degeneratively to the input circuit of the amplifier so as to cancel substantially the entire gain of the amplifier.

5. An electric system selective to predetermined frequencies having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means for degeneratively coupling the output circuit to the input circuit in order to reduce the effective gain of the amplifier, and means for rendering the degenerative coupling substantially ineffective at said predetermined frequencies, said means including one or more variable circuit elements for the purpose of varying said predetermined frequencies, the system as a whole having parameters such as to provide substantially maximum transmission at the said predetermined frequencies in order to render the system as a whole selective to the said predetermined frequencies.

6. An electric system having maximum transmission at a single frequency and comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, and means for degeneratively coupling the output circuit to the input circuit in order to reduce the effective gain of the amplifier, the said means having substantially minimum transmission at said single frequency, and including one or more variable circuit elements, and the system as a whole having parameters such as to provide substantially maximum transmission at the said single frequency in order to render the system as a whole selective at the said single frequency.

7. An electric system having maximum transmission at a single frequency and comprising, in combination, a source of energy, a direct-coupled multi-stage amplifier having an input circuit coupled to the source and an output circuit, and means for degeneratively coupling the output circuit to the input circuit, the said means comprising a network having common input and output terminals and unprovided with mutually inductive elements, but having substantially zero coupling at said single frequency and including one or more variable circuit elements for the purpose of adjusting the frequency to which the system is selective.

8. An electric system giving peaked response, selectively, at a predetermined frequency or within a predetermined band of frequencies having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means for degeneratively coupling the output circuit to the input circuit in order to reduce the effective gain of the amplifier, and means for rendering said degenerative coupling substantially ineffective at said predetermined frequency or frequencies, said means including two or more variable circuit elements for varying the said predetermined frequency or frequencies, and means for simultaneously ad-

justing two or more of the variable circuit elements.

9. An electric system comprising a network and selective with regard to a predetermined frequency or frequencies as predetermined by the characteristics of the component circuit elements of the network, the said electric system having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising the network for degeneratively coupling the output circuit to the input circuit in order to reduce the effective gain of the amplifier, and means for rendering said degenerative coupling substantially ineffective at said predetermined frequency or frequencies, said means including means for switching one or more of the circuit elements into or out of the degenerative coupling network for the purpose of changing the frequency or frequencies to which the system is selective.

10. An electric system having maximum transmission at a single frequency and comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means for degeneratively coupling the output circuit to the input circuit, said means having substantially zero transmission at said single frequency and comprising a network containing resistances and capacitances only, and means for varying one or more of said resistances and capacitances for the purpose of adjusting the frequency to which the system is selective, the system having parameters such that the system as a whole provides substantially maximum transmission at the said single frequency.

11. An electric system selective to predetermined frequencies and comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means for degeneratively coupling the output circuit to the input circuit, and means for rendering the degenerative coupling means substantially ineffective at said predetermined frequencies, the first-named means comprising a three-terminal network having one terminal common to the input and output circuits and the other two terminals respectively connected to the input and output circuits, the system as a whole having parameters such as to provide substantially maximum transmission at the said predetermined frequencies in order to render the system as a whole selective to the said predetermined frequencies.

12. An electric system having maximum transmission at a single frequency and comprising, in combination, a source of energy, a direct-coupled multi-stage amplifier having an input circuit coupled to the source and an output circuit, means for degeneratively coupling the output circuit to the input circuit, said means having substantially zero coupling at said single frequency and comprising a Wheatstone bridge having a plurality of circuit elements comprising resistances in all four arms thereof, a capacitance in series with one of said resistances, and a second capacitance in parallel with another of said resistance and means for varying one or more of the circuit elements in said bridge for the purpose of adjusting the frequency to which the system is selective.

13. An electric system selective to a single frequency and comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means for degeneratively coupling the output circuit to the input circuit, said means having substantially zero coupling at said single frequency and comprising a parallel-T network, and means for adjusting one or more of the circuit elements in said network for the purpose of selecting the frequency to which the system is selective.

14. An electric system selective with regard to frequency and comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a parallel-T network containing resistances and capacitances only for degeneratively coupling the output circuit to the input circuit, said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, means for adjusting all resistances therein simultaneously for continuous adjustment of the frequency to which the system is selective, and means comprising a multi-pole switch for switching the capacitances into said circuit selectively to adjust in steps the frequency to which the system is selective.

15. An electric system having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a parallel-T network containing a plurality of resistors and a plurality of capacitors for degeneratively coupling the output circuit to the input circuit, the said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, means for adjusting the capacitors continuously, and means for switching the resistors into circuit selectively.

16. An electric system having maximum transmission at a single frequency and comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means for degeneratively coupling the output circuit to the input circuit, said means having substantially zero coupling at said single frequency and comprising a bridged-T network, and the system as a whole having parameters such as to provide substantially maximum transmission at the said single frequency in order to render the system as a whole selective at the said single frequency.

17. An electric system selective to predetermined frequencies comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a network for degeneratively coupling the output circuit to the input circuit, and means for rendering said degenerative coupling substantially ineffective at said predetermined frequencies and for varying the gain of said amplifier for the purpose of varying the selectivity of the system, the system as a whole having parameters such as to provide substantially maximum transmission at the said predetermined frequencies in order to render the system as a whole selective at the said predetermined frequencies.

18. An electric system selective to predetermined frequencies having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means for degeneratively coupling the output circuit to the input circuit, and means for rendering the degenerative coupling means substantially ineffective at said predetermined frequencies, said degenerative coupling means comprising a passive network and a second amplifier, the system as a whole having parameters such as to provide substantially maximum transmission

at the said predetermined frequencies in order to render the system as a whole selective at the said predetermined frequencies.

19. An electric system comprising a first circuit having an input circuit and an output circuit, a second circuit having an input circuit and an output circuit and having a characteristic curve such that the transmission of the second circuit shall be rendered substantially ineffective at a predetermined frequency or frequencies, and means for coupling the second-named input circuit to the first-named output circuit and the second-named output circuit to the first-named input circuit to feed back energy from the first-named output circuit to the first-named input circuit through the second circuit, the system comprising means for effecting a reversal of phase between the voltage in the first-named input circuit and the voltage applied to the first-named input circuit by the second-named output circuit, the system as a whole having parameters such as to provide substantially maximum transmission at the said predetermined frequency or frequencies in order to render the system as a whole selective to the said predetermined frequency or frequencies.

20. An electric system comprising an amplifier having an input circuit and an output circuit, a network having a characteristic curve such that the transmission of the network shall be rendered substantially ineffective at a predetermined frequency or frequencies, and means for degeneratively coupling the output circuit to the input circuit to feed back energy from the output circuit to the input circuit through the network, the system comprising means for effecting a reversal of phase between the voltage of the input circuit and the voltage applied to the input circuit by the network, the system as a whole having parameters such as to provide substantially maximum transmission at the said predetermined frequency or frequencies in order to render the system as a whole selective at the said predetermined frequency or frequencies.

21. An electric system comprising an amplifier having an input circuit and an output circuit, a three-terminal network having a characteristic curve such that the transmission of the network shall be rendered substantially ineffective at a predetermined frequency or frequencies, and means connecting two of the terminals of the network to the output circuit and one of the said two terminals and the third terminal of the network to the input circuit to feed back energy from the output circuit to the input circuit through the network, the system comprising means for effecting a reversal of phase between the voltage in the input circuit and the voltage applied to the input circuit by the network, the system as a whole having parameters such as to provide substantially maximum transmission at the said predetermined frequency or frequencies in order to render the system as a whole selective at the said predetermined frequency or frequencies.

22. An electric system comprising a network and selective with regard to frequency as predetermined by the characteristics of the component circuit elements of the network, the said electric system having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, and means comprising the network for degeneratively coupling the output circuit to the input circuit, the network having common input and output terminals and having substantially zero transmission at the predetermined frequency.

23. An electric system comprising a network and selective with regard to frequency as predetermined by the characteristics of the component circuit elements of the network, the said electric system having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising the network for degeneratively coupling the output circuit to the input circuit, the network having common input and output terminals and having substantially zero transmission at the predetermined frequency, and means for adjusting said component elements to adjust the predetermined frequency.

24. An electric system comprising a network and selective with regard to frequency as predetermined by the characteristics of the component circuit elements of the network, the said electric system having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, the amplifier comprising more than one stage, one of the stages being directly coupled to a previous stage, and means comprising the network for degeneratively coupling the output circuit to the input circuit, the network having substantially zero transmission at the predetermined frequency.

25. An electric system comprising a network and selective with regard to frequency as predetermined by the characteristics of the component circuit elements of the network, the said electric system having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, the amplifier comprising more than one stage, one of the stages being directly coupled to a previous stage, means comprising the network for degeneratively coupling the output circuit to the input circuit, the network having substantially zero transmission at the predetermined frequency, and means for adjusting said component elements to adjust the predetermined frequency.

26. An electric system comprising a network and selective with regard to frequency as predetermined by the characteristics of the component circuit elements of the network, the said electric system having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, the amplifier comprising a plurality of tubes each having a cathode, a grid and an anode, input and output circuits for each tube comprising, respectively, the grid and the cathode, and the plate and the cathode, of the respective tubes, each grid of each tube except the first being galvanically connected to the plate of the preceding tube, and means comprising the network for degeneratively coupling the output circuit of the amplifier to the input circuit of the amplifier, the network having a common input terminal and output terminal and having substantially zero transmission at the predetermined frequency.

27. An electric system comprising a network and selective with regard to frequency as predetermined by the characteristics of the component circuit elements of the network, the said electric system having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, the amplifier comprising a plurality of tubes each having a cathode, a grid and an anode, input and output circuits for each tube comprising, respectively, the grid and the cathode, and the plate and the

cathode, of the respective tubes, each grid of each tube except the first being galvanically connected to the plate of the preceding tube, means comprising the network for degeneratively coupling the output circuit of the amplifier to the input circuit of the amplifier, the network having a common input terminal and output terminal and having substantially zero transmission at the predetermined frequency, and means for adjusting said component elements to adjust the predetermined frequency.

28. An electric system selective with regard to frequency and comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a bridged-T network for degeneratively coupling the output circuit to the input circuit, the network having substantially zero transmission at a frequency determined by the characteristics of its component elements, and means for adjusting said component elements for adjustment of the frequency to which the system is selective.

29. An electric system selective with regard to frequency having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a parallel-T network containing a plurality of resistors and a plurality of capacitors for degeneratively coupling the output circuit to the input circuit, the said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, and means for adjusting the values of the component parts of said network for the purpose of changing the frequency to which the system is selective.

30. An electric system selective with regard to frequency having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a parallel-T network containing a plurality of resistors and a plurality of capacitors for degeneratively coupling the output circuit to the input circuit, the said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, and means for adjusting simultaneously the values of two or more of the component parts of said network for the purpose of changing the frequency to which the system is selective.

31. An electric system selective with regard to frequency and comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a three-terminal network containing resistances and capacitances only for degeneratively coupling the output circuit to the input circuit, said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, means for adjusting all resistances therein simultaneously for continuous adjustment of the frequency to which the system is selective, and means comprising a multi-pole switch for switching the capacitances into said circuit selectively to adjust in steps the frequency to which the system is selective.

32. An electric system selective with regard to frequency having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a three-terminal network containing a plurality of resistors and a plurality of capacitors for degeneratively coupling the output circuit to the input circuit, the said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, means for adjusting the capacitors continuously, and means for switching the resistors into the circuit selectively.

33. An electric system selective with regard to frequency having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a three-terminal network containing a plurality of resistors and a plurality of capacitors for degeneratively coupling the output circuit to the input circuit, the said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, and means for adjusting the values of the component parts of said network for the purpose of changing the frequency to which the system is selective.

34. An electric system selective with regard to frequency and comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a parallel-T network containing resistances and capacitances only for degeneratively coupling the output circuit to the input circuit, said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, means for adjusting all resistances therein simultaneously for continuous adjustment of the frequency to which the system is selective, means comprising a multi-pole switch for switching the capacitances into said circuit selectively to adjust in steps the frequency to which the system is selective, and means for indicating the output voltage or energy of the system.

35. An electric system having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a parallel-T network containing a plurality of resistors and a plurality of capacitors for degeneratively coupling the output circuit to the input circuit, the said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, means for adjusting the capacitors continuously, means for switching the resistors into the circuit selectively, and means for indicating the output voltage or energy of the system.

36. An electric system, selective with regard to frequency and comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a three-terminal network containing resistances and capacitances only for degeneratively coupling the output circuit to the input circuit, said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, means for adjusting all resistances therein simultaneously for continuous adjustment of the frequency to which the system is selective, means comprising a multi-pole switch for switching the capacitances into said circuit selectively to adjust in steps the frequency to which the system is selective, and means for indicating the output voltage or energy of the system.

37. An electric system having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a three-terminal network containing a plurality of resistors and a plurality

of capacitors for degeneratively coupling the output circuit to the input circuit, the said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, means for adjusting the capacitors continuously, means for switching the resistors into the circuit selectively, and means for indicating the output voltage or energy of the system.

38. An electric system, selective with regard to frequency and comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means for degeneratively coupling the output circuit to the input circuit, said means comprising a network having common input and output terminals, said network having substantially zero transmission at a frequency determined by the characteristics of the component elements, and means for adjusting said component elements for adjustment of the frequency to which the system is selective.

39. An electric system selective with regard to frequency having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a parallel-T network containing a plurality of resistors and a plurality of capacitors for degeneratively coupling the output circuit to the input circuit, the said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, and means for adjusting the transmission characteristics of said network for the purpose of adjusting the selectivity of the system.

40. An electric system, selective with regard to frequency, having, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, means comprising a parallel-T network containing a plurality of resistors and a plurality of capacitors for degeneratively coupling the output circuit to the input circuit, the said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, and means for adjusting the gain of said amplifier for the purpose of adjusting simultaneously the gain and selectivity of the system.

41. An electric system, selective with regard to frequency and comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, and means comprising a parallel-T network containing resistances and capacitances only for degeneratively coupling the output circuit to the input circuit, said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, and said amplifier having an odd number of amplifying stages in order to provide substantially 180 degrees phase shift between the input and output circuits.

42. An electric system, selective with regard to frequency and comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, and means comprising a parallel-T network containing resistances and capacitances only for degeneratively coupling the output circuit to the input circuit, said network having substantially zero transmission at a frequency determined by the characteristics of its component elements, and said amplifier comprising a plurality of amplifying stages including vacuum tubes, with the grid of each tube except the first connected directly to the plate of the tube in the preceding stage.

43. An electric system, selective with regard to frequency and comprising, in combination, a source of energy, an amplifier having an input circuit coupled to the source and an output circuit, and means comprising a parallel-T network containing resistances and capacitances only for degeneratively coupling the output circuit to the input circuit, said network having substantially zero coupling at a frequency determined by the characteristics of its component elements, and said amplifier including means for reversing the phase between the input and output circuits.

44. An electric system comprising a plurality of successively connected vacuum tubes each having a cathode, a grid and an anode, an input circuit of each tube connected to the grid and the cathode and an output circuit connected to the anode and the cathode of each tube, the grid of one or more of the tubes being galvanically connected to the anode of the preceding tube, said one or more of the tubes having a resistor and a condenser in parallel in common to its or their input and output circuits.

45. An electric system comprising a plurality of successively connected tubes each having a cathode, a grid and an anode, an input circuit of each tube connected to the grid and the cathode and an output circuit connected to the anode and the cathode of each tube, the grid of one or more of the tubes being galvanically connected to the anode of the preceding tube, said one or more of the tubes having a resistor in common to its or their input and output circuits, the said resistor being connected also in one of the tubes preceding the said one or more of the tubes.

46. An electric system comprising a plurality of successively connected vacuum tubes each having a cathode, a grid and an anode, an input circuit of each tube connected to the grid and the cathode and an output circuit connected to the anode and the cathode of each tube, the grid of one or more of the tubes being galvanically connected to the anode of the preceding tube, said one or more of the tubes having a resistor in common to its or their input and output circuits, the said resistor being connected also in the input circuit of one of the tubes preceding the said one or more of the tubes.

47. An electric system comprising a plurality of successively connected vacuum tubes each having a cathode, a grid and an anode, an input circuit of each tube connected to the grid and the cathode and an output circuit connected to the anode and the cathode of each tube, the grid of one or more of the tubes being galvanically connected to the anode of the preceding tube, said one or more of the tubes having a resistor and a condenser in parallel in common to its or their input and output circuits, the said resistor and condenser being connected also in one of the tubes preceding the said one or more of the tubes.

48. An electric system comprising a plurality of successively connected vacuum tubes each having a cathode, a grid and an anode, an input circuit of each tube connected to the grid and the cathode and an output circuit connected to the anode and the cathode of each tube, the grid of one or more of the tubes being galvanically connected to the anode of the preceding tube, said one or more of the tubes having a resistor and a condenser in parallel in common to its or their input and output circuits, the said resistor and condenser being connected also in the input circuit of

one of the tubes preceding the said one or more of the tubes.

49. An electric system comprising a plurality of vacuum tubes each having a cathode, a grid and an anode, an input circuit of each tube connected to the grid and the cathode and an output circuit connected to the anode and the cathode of each tube, the grid of one or more of the tubes being galvanically connected to the anode of the preceding tube, said one or more of the tubes having a resistor in common to its or their input and output circuits, means for degeneratively coupling the output of the system to the input of the system, and means for rendering said coupling means ineffective at a predetermined frequency.

50. An electric system comprising a plurality of vacuum tubes each having a cathode, a grid and an anode, an input circuit of each tube connected to the grid and the cathode and an output circuit connected to the anode and the cathode of each tube, the grid of one or more of the tubes being galvanically connected to the anode of the preceding tube, said one or more of the tubes having a resistor and a condenser in parallel in common to its or their input and output circuits, means for degeneratively coupling the output of the system to the input of the system, and means for rendering said coupling means ineffective at a predetermined frequency.

HERMON H. SCOTT.

Pages 1133 To 1140

2,201,311 1133

DEFENDANT'S EXHIBIT O-14

Halliburton Patent No. 2,201,311

[Endorsed]: Filed Nov. 4, 1942.

1134

May 21, 1940. E. P. HALLIBURTON 2,201,311

APPARATUS FOR INDICATING THE POSITION OF DEVICES IN PIPES

Filed Dec. 24, 1936 2 Sheets-Sheet 1

Fig. 1.

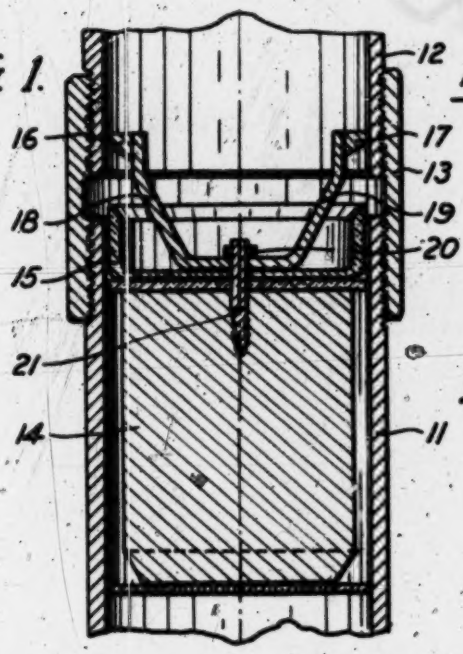


Fig. 3.

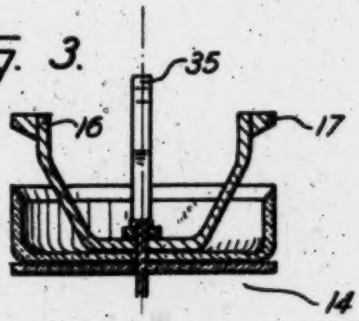


Fig. 4.

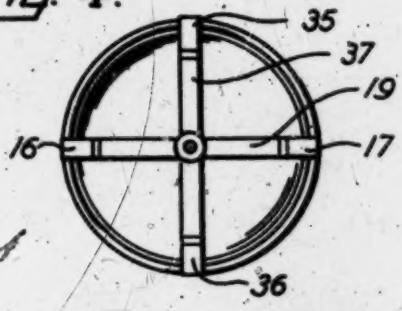


Fig. 2.

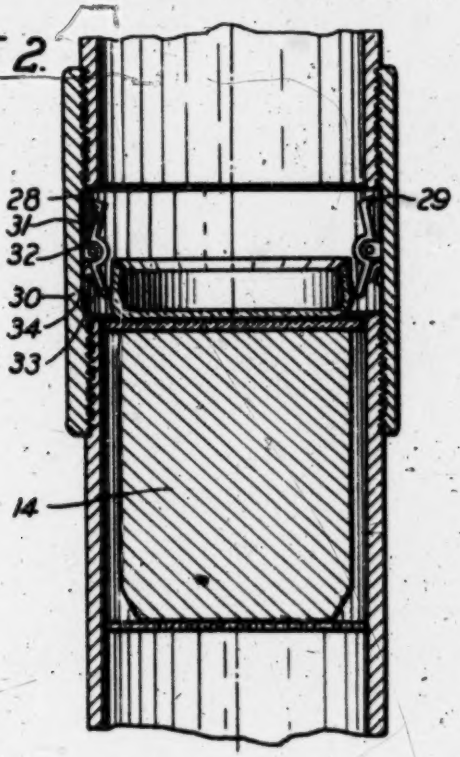


Fig. 10.

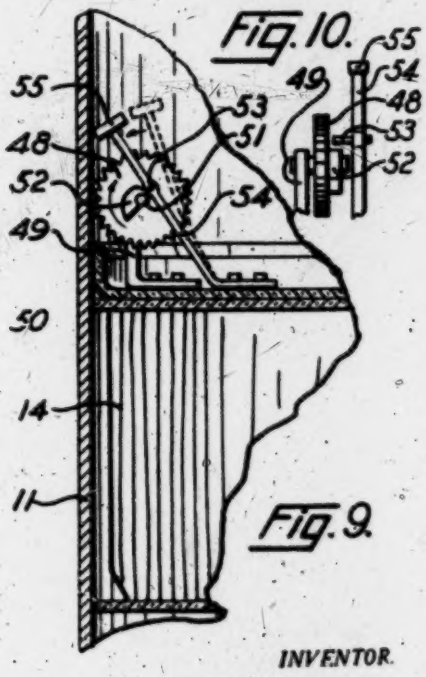


Fig. 9.

INVENTOR.
Erle P. Halliburton.
BY Earl Babcock
ATTORNEY

1136

May 21, 1940. E. P. HALLIBURTON 2,201,311

APPARATUS FOR INDICATING THE POSITION OF DEVICES IN PIPES

Filed Dec. 24, 1936 2 Sheets-Sheet 2

Fig. 5.

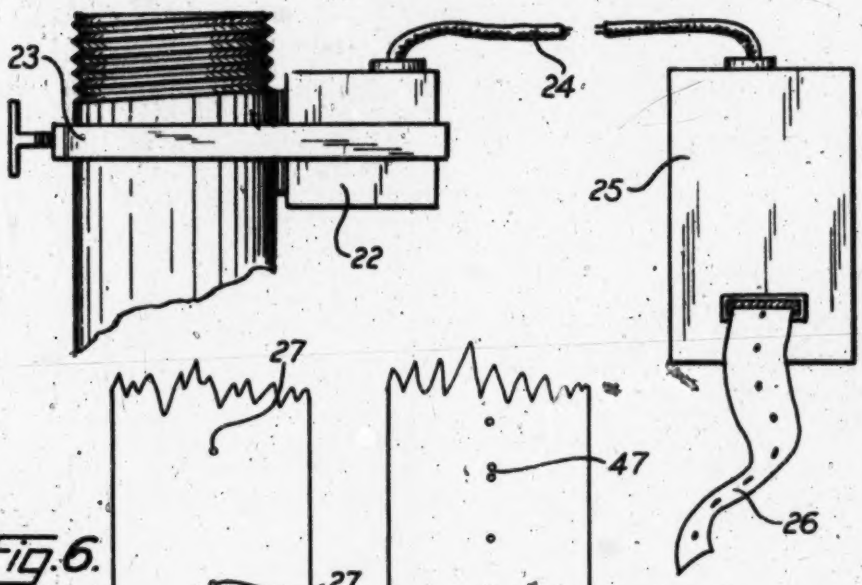


Fig. 6.

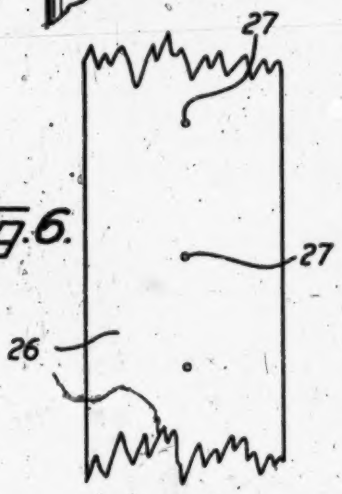


Fig. 7.

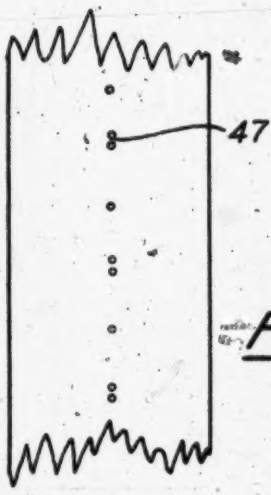
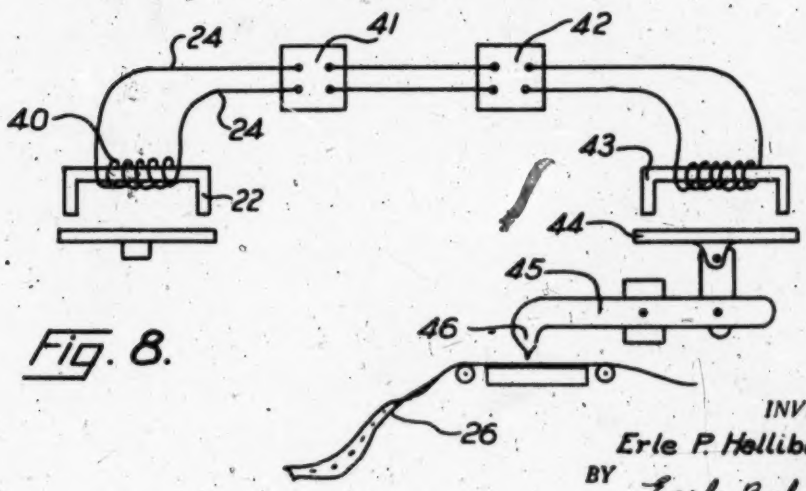


Fig. 8.



INVENTOR.
Erle P. Halliburton.
BY Earl Babcock.
ATTORNEY

Patented May 21, 1940 2,201,311

UNITED STATES PATENT OFFICE

2,201,311

APPARATUS FOR INDICATING THE POSITION OF DEVICES IN PIPES

Erle P. Halliburton, Los Angeles, Calif., assignor to Halliburton Oil Well Cementing Company, Duncan, Okla.

Application December 24, 1936, Serial No. 117,504

6 Claims. (Cl. 181—0.5)

This invention relates to the apparatus for indicating the position of devices passing through pipes and more particularly to means for indicating the position of the devices by the transmission of sound or vibrations through the pipes.

It is often desirable to know the position of a plug or other element moving through a pipe or casing. For example, in the cementing of an oil well where one or more plugs are used in placing the cement in a particular part of the well, it is desirable to keep track of the position of at least the upper plug. It has been common practice heretofore to use a measuring line for this purpose. Examples of means for accomplishing this are disclosed in my prior patents, No. 1,369,891, granted March 1, 1921, for Method and means for cementing oil wells, and No. 1,892,037, granted November 20, 1928, for Well sounding device.

The use of a measuring line as illustrated in the patents mentioned above has certain disadvantages. The well is subjected to high pressures during the cementing operations, so the measuring line must travel through a stuffing box or gland and this sometimes causes difficulties. Also, the measuring line sometimes breaks in the well and becomes tangled and difficult to remove. Moreover, and particularly in very deep wells, it is not always certain that the lower end of the measuring line is following the plug and the readings of distance are not always accurate because the measuring line stretches.

It is also to be noted that where a measuring line is employed in the cementing of an oil well an indication can be obtained only of the position of the upper plug.

It is an object of the present invention to overcome these and other difficulties by doing away with the measuring line altogether.

It is another object of the invention to devise an apparatus by which the position of a plug or other object in the casing of a well, or the like, can be accurately determined at all times as the result of vibrations set up in the casing.

It is still another object of the invention to devise means for determining or recording the position of a plurality of plugs or like devices within a casing.

It is still another object of the invention to devise means for indicating when a plug has arrived at a predetermined point within the casing of an oil well, or the like.

Other objects and advantages reside in certain novel features of the apparatus, as will be apparent from the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a vertical cross-sectional view of the portion of a casing with a cementing plug therein, the cementing plug having means thereon constructed in accordance with the present invention for use in determining the position of the plug.

Fig. 2 is a vertical cross-sectional view of a portion of casing and with an ordinary cementing plug therein, the casing being provided with means constructed in accordance with the present invention for indicating when the plug has reached a certain predetermined position in the casing.

Fig. 3 is a vertical cross-sectional view of the upper portion of a plug similar to that illustrated in Fig. 1, but with a modified form of sounding or vibrating device.

Fig. 4 is a plan view of the plug shown in Fig. 3.

Fig. 5 is a side view of the top of a casing in a well with apparatus constructed in accordance with the present invention secured thereto, together with a showing of the associated recording apparatus.

Fig. 6 is a plan view of a fragment of tape taken from the recorder of Fig. 5 upon which a record of the passage of one plug has been made.

Fig. 7 is a view similar to that of Fig. 6, but showing the recording of two plugs thereon.

Fig. 8 is a diagrammatic showing of the electrical connections between the detecting and recording apparatus of the invention.

Fig. 9 is a cross-sectional view of a plug with still another kind of sounding device thereon; and

Fig. 10 is a side view of a portion of the apparatus of Fig. 9.

Referring to the drawings in detail, and first to the arrangement of Fig. 1, it will be seen that a portion of a jointed pipe or casing is there illustrated as consisting of two sections or stands of pipe designated 11 and 12, these being joined by a collar 13 of conventional construction. As shown, an annular space is ordinarily present just inside the collar, since the sections 11 and 12 are not in abutting relation.

Within the casing a plug 14 is located. This plug may be of the general type shown in my Patent No. 1,369,891 mentioned above, or it may be of any other suitable known construction. It is preferably provided with a suitable washer or packing element 15, at its upper end. In accordance with the present invention, the ordinary

plug is modified to the extent that it is provided with one or more knockers. These may be mounted on the top of the plug as shown at 16 and 17.

The knockers should be made of metal so as to cause a distinct vibration in the casing when they strike the same. They may be mounted on the plug by means of leaf springs 18 and 19, which are so constructed as to press the knockers against the wall of the casing as the plug moves downwardly therethrough. The springs 18 and 19 may be integral and secured to the plug 14 by means of the bolt and nut 20 and 21, which also secure the washer 15 to the plug.

The arrangement is such that as the plug moves downwardly through the casing the knockers 16 and 17 will strike against the casing and make a noise or vibration therein every time the plug passes a collar 13.

In accordance with the present invention it is proposed to provide means for counting the number of times the knockers strike the casing and in this way determine how many collars or joints the plug has passed through. In this way it is possible to locate the position of the plug at any time without measuring.

Accordingly, the sound or vibration in the casing caused by the knockers 16 and 17 is transmitted to the surface of the well through the casing. It is known that a casing is a good conductor of sound or vibration, and if the knockers are so designed as to strike the casing sharply, no trouble is experienced in detecting the sound and in distinguishing it from other noises or vibrations around the oil well, especially where the detecting apparatus of the present invention is used.

It is known in seismographic geophysical exploration to pick up and record vibrations or sounds from the earth. The detectors of such seismographic apparatus usually consists of a casing which is subjected to the vibration or tremor and a bob weight or inertia element which remains substantially stationary while the casing moves. Relative movement between the casing and weight causes an armature to move with respect to the field piece or core of an electro-magnet and thus the vibrations are transmuted into electrical impulses and cause a current of electricity to flow through the coil of the magnet. This current may be amplified and recorded.

A detector similar to that used in seismographic work may be used in the present invention, but the circuit is preferably modified to some extent.

In Fig. 5 the detector is illustrated at 22 and is shown clamped to the top of the casing by means of a band 23. It will be apparent that the casing of the detector 22 will be vibrated as the casing vibrates in response to the striking of the knockers 16 and 17 at various places down in the well.

As illustrated in Fig. 8, electrical impulses will be set up within a coil 40 in the detector 22 and these may be transmitted through an electrical conductor cable 24 to a recording or indicating box 25.

Now it is known that electrical impulses of comparatively low frequencies, such, for example, as the frequencies which correspond to audible sound, can be filtered to remove all impulses of other frequencies. If, therefore, a suitable filter is provided within the recording apparatus 25, as shown at 41, the recording instrument therein will receive only the impulses caused by the knockers 16 and 17 striking the casing. It is preferable also to provide some electrical amplifying circuit within the recorder 25, and this is shown at 42 in Fig. 8.

The recording apparatus, per se, may consist merely of an electro-magnet 43, the armature 44 of which is connected by link mechanism 45 to a stylus 46 adapted to strike a strip of tape 26 when the electro-magnet 43 is energized.

The recording tape 26 may be so arranged that the tape is moved and a mark made thereon every time the knockers 16 and 17 strike the casing. The mechanism for accomplishing this may be similar to that employed in stock market tickers. On the other hand, the tape may be moved at a constant rate of speed by clockwork. In either case the tape may be marked as shown in Fig. 6, as illustrated at 27, each mark indicating that the knockers 16 and 17 have struck the casing. Thus by counting the dots 27 on the tape the number of stands of casing which have been passed by the plug can be determined.

The arrangement shown in Fig. 1 and described above, is best suited for use where the casing has collars or joints and where there is a space between the bottom of one stand of casing and the top of the adjacent one. It has become common in modern casing methods to weld one stand of pipe to the next without the use of the collar, however, and the apparatus of Fig. 1 could not be successfully used in such a casing, unless the casing were specially prepared, with obstructions or the like, to actuate the knockers.

An arrangement especially suitable for use in welded casing is shown in Fig. 2. It is unnecessary in cementing operations to know the exact position of the cementing plug until, or just before, it reaches the point where it is desired to have it remain stationary. It is possible, therefore, to provide the casing with specially made collars at or near the point where it is desired that the plug shall be brought to rest. Thus, as illustrated in Fig. 2, knockers 28 and 29 are mounted in a special collar 30, rather than on a plug 14. The knockers 28 and 29 are mounted upon levers 31 pivoted to supports 32 integral with the collar 30. The levers have bell crank portions 33 adapted to contact the plug 14 and be depressed thereby into the position shown in Fig. 2 when the plug 14 is in contact therewith. Suitable leaf springs 34 are provided, tending to force the knockers 28 and 29 into contact with the collar. Thus, when the plug 14 passes a collar 30 the knockers 28 and 29 strike the collar and vibrations will be transmitted to the surface of the well just as in the arrangement of Fig. 1.

With the arrangement of Fig. 2 it may be desirable to connect several collars 30 into the casing as it is being made up so that as the plug 14 passes the upper collar a warning vibration will be transmitted to the surface and as it passes the next lower collar or collars, its exact position can be indicated.

An advantage in the arrangement of Fig. 2 over that of Fig. 1, where used in a cementing operation, is that it will be unnecessary to drill up the knockers and springs after the well is cemented and drilling operations in the well are continued.

A particular advantage of the present invention results from the fact that the position of two or more plugs within the casing can be kept track of. One way of accomplishing this is to provide for distinguishing knocks on separate plugs.

e arrangement of Figs. 3 and 4, the knock-
e been so constructed as to cause a double
as the plug there shown passes a collar.
lug, in addition to having knockers 16 and
those shown in Fig. 1, is provided with an
nal pair 35 and 36 mounted upon addi-
springs 37 disposed at 90 degrees relation
espect to the springs 18 and 19.
springs 37 are longer than the springs 18
so that the knockers 35 and 36 strike the
after the knockers 16 and 17 strike the
as the plug moves downwardly in the well.
a double knock is effected, which is readily
ed from the single knock where only the
ers 16 and 17 are fixed to the plug.
vill be apparent therefore that where two
are passing downwardly within a casing,
f which is provided with a single pair of
s, as in the arrangement of Fig. 1, and the
of which is provided with a double pair of
ers, as in the arrangement of Figs. 3 and 4,
ord may be obtained upon the tape 26, as
ated at 47 in Fig. 7, which will show the po-
of both plugs. By counting the double dots
the tape the position of one plug can be de-
ned and by counting the number of single
on the tape, the position on the other plug
e determined.
linarily, where two plugs are being passed
wardly through a casing in a cementing op-
on they remain a constant distance apart,
the casing splits or if mud or fluid cement
aking past one of the plugs they may ap-
ch each other and this will be indicated on
ap
an electrical magnet is used to mark the dots
the tape in response to impulses set up in
letector 22, as illustrated in Fig. 8, it may
times happen that the magnet will be mark-
dot upon the tape as the result of the knock-
n one plug striking the casing at the same
that the knockers on another plug are trans-
ng an impulse. This can ordinarily be
ly detected upon the tape, however, because
mpulses do not remain in exact synchronism.
Figs. 9 and 10, a modified form of sounding
nocking device is illustrated. To the top of
plug 14, a toothed wheel 48 is secured by
s of the leaf spring 49, bolted to the plug by
50. The shaft 51 supporting the wheel 48
les a cam 52 which cooperates with a pin 53
ed by a leaf spring 54, the lower end of which
ited to the plug and the upper end of which
les the knocker 55. The teeth on the wheel
nder the influence of the spring 49, bite into
casing and effectively gear the wheel to the
g so that as the plug goes down the wheel
rotate in proportion to its movement. Thus
arrangement is such that the cam 52 will
e the knocker 55 to strike the casing once
ach rotation of the wheel 48, and the move-
t of the plug can be kept track of, by the
-up apparatus at the surface.

It will be apparent to those skilled in the art that instead of using a recording apparatus which marks the tape 26 in the arrangement of Fig. 5, that the tape may be previously calibrated, say with marks thereon an inch apart which will represent one section or stand of casing, and the arrangement may be such that the tape is advanced this unit distance by the apparatus for each knock made upon the casing as the plug moves.

While only a few embodiments have been shown and described herein, it is obvious that various changes may be made without departing from the spirit of the invention or the scope of the annexed claims.

I claim:

1. The combination with a jointed pipe of a device therein and apparatus for indicating the position of the device in the pipe, said apparatus comprising means for setting up a vibration in said pipe each time said device passes a joint therein, thereby producing a number of successive vibrations and means for detecting and recording the successive vibrations in the pipe to determine and record the number of joints the device has passed at any instant.

2. The combination with the casing of an oil well or the like, of a plug adapted for use in cementing the well, resilient means mounted on the plug, a knocker mounted on said resilient means and adapted to strike the casing.

3. A plug adapted for use in cementing an oil well or the like, said plug having a main body portion, a knocker and resilient means connected to the main body portion and to said knocker to mount the knocker on the plug.

4. In an oil well or the like, the combination with the casing thereof of a knocker mounted on the casing within the well, an object within the casing, means adapted to cause the knocker to strike the casing when said object passes through the casing past the knocker and means at the surface of the well for detecting the position of said object as the result of the knocker striking the casing.

5. In an oil well or the like, a casing, a knocker mounted on the casing within the well, an object in the casing, said knocker having means associated therewith and cooperating with said object to cause the knocker to strike the casing when the object passes through the casing past the knocker.

6. Apparatus adapted for use in the cementing of an oil well or the like, including a plurality of plugs adapted to pass through the casing of the well in succession and a system for indicating the position of more than one of said plugs said system including means cooperating with the plugs and casing for creating vibrations in the casing as the plugs pass certain points therein and means at the surface of the well for indicating said vibrations.

ERLE P. HALLIBURTON.

CLERK'S COPY.

Vol. V

TRANSCRIPT OF RECORD

(Pages 1141 to 1592)

Supreme Court of the United States

OCTOBER TERM, [illegible] 1946

No. [illegible] 24

HALLIBURTON OIL WELL CEMENTING COMPANY,
PETITIONER,

vs.

CRANFORD P. WALKER AND CRANFORD P. WALKER, D. A. WALKER, ET AL., DOING BUSINESS AS DEPTHOGRAPH COMPANY, COPARTNERSHIP

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT

PETITION FOR CERTIORARI FILED AUGUST 2, 1946.

CERTIORARI GRANTED OCTOBER 15, 1946.

Office - Supreme Court, U. S.
FILED
AUG 2 1945
CHARLES ELMORE CROPLEY
CLERK

TRANSCRIPT OF RECORD
IN SIX VOLUMES

IN THE

Supreme Court of the United States

October Term, 1945

No. 290

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Petitioner,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Respondents.

VOLUME V

Book of Exhibits
(Defendant's Exhibits—Part II)
Pages 1141 to 1591

UPON PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT

Rotary Colorprint, 661 Howard Street, San Francisco

No. 10513

United States
Circuit Court of Appeals
For the Ninth Circuit.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Appellant,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Appellees.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Appellants,

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Appellee.

Transcript of Record
In Five Volumes
VOLUME V
Book of Exhibits
(Defendant's Exhibits—Part II)
Pages 1141 to 1591

Upon Appeals from the District Court of the United States for the Southern District of California, Central Division

Rotary Colorprint, 590 Folsom St., San Francisco

DEFENDANT'S EXHIBIT Q

309

Department of Commerce
United States Patent Office

To all persons to whom these presents shall come, Greeting:

This is to certify that the annexed is a true copy from the records of this office of the File Wrapper and Contents, in the matter of the

Abandoned Application of
Cranford P. Walker,

Serial Number 171,170
for
Improvement in Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

In Testimony Whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this fourth day of November, in the year of our Lord one thousand nine hundred and forty-one and of the Independence of the United States of America the one hundred and sixty-sixth.

[Seal] CONWAY P. COE
Commissioner of Patents.

Attest:
D. E. WILSON,
Chief of Division.

NUMBER (Series of 1935)

171170

DIV. 44 3K

PATENT NO.

DATED MAY - 2 1939

(EX'R'S BOOK) 54, 493/37

ABANDONED

Name CRAWFORD P. WALKER

This application referred to in Patent No. 2161733 Do not destroy. (See order No. 3166, 400 O.G. 1)

DO NOT DETACH

of SAN MARINO

State of CALIFORNIA

Invention METHOD OF DETERMINING FLUID DENSITY, FLUID PRESSURE, AND PRODUCTION CAPACITY OF OIL WELLS

Defendant's Exhibit Q—(Continued)

Mail Division Oct 25 1937 U. S. Patent Office.

Harold W. Mattingly
Attorney at Law
Patent and Trademark Causes
924 Pacific Finance Building
621 South Hope Street
Los Angeles, California
MAdison 1137

October 22, 1937.

Oct-26-37 O 76887D Check—30.0
Oct-26-37 O 76387D Check—14.0
1/86

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Attached is application for Letters Patent of the United States executed October 20, 1937 by Cranford P. Walker for Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells; also attached is my check No. 271 in the amount of $44.00 to cover the Government filing fee. (34 claims).

Respectfully,
HAROLD W. MATTINGLY.

MM
Encls.

Defendant's Exhibit Q—(Continued)
U. S. Patent Office Nov. 3-1937. Division 36.
Mail Division Oct. 25-1937. U. S. Patent Office.

PETITION

To the Commissioner of Patents:

Your petitioner, Cranford P. Walker, a citiz. of the United States, residing at San Marino, in the County of Los Angeles, and the State of California, whose post office address is 2824 Carlaris Road, San Marino, California, prays that Letters Patent may be granted to him for the Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells set forth in the annexed specification, and he hereby appoints

Harold W. Mattingly
924 Pacific Finance Building
621 South Hope Street
Los Angeles, California
(Registry No. 12,385)

his attorney with full power to substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.

(Sign here first name in full)

CRANFORD P. WALKER.

SPECIFICATION

To All Whom It May Concern:

Be It Known, That I, Cranford P. Walker, a citi-

Defendant's Exhibit Q—(Continued)

zen of the United States, residing at San Marino, in the County of Los Angeles, and State of California, have invented certain new and useful improvements in Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells of which the following is a specification:

My invention relates to methods of determining the fluid density, fluid pressure and potential production capacity of oil wells and has particular reference to methods of determining the most desirable character of pumping equipment and manner of operating the same to permit an efficient production of oil from a given well.

It is the common practice in oil well production activity to permit an oil well to produce as a flowing well, that is to permit the oil to flow out at the ground surface due to the pressure in the oil formations, until the production rate reaches a considerably low value or ceases, after which gas lifting is usually attempted and continued until the production rate with gas lifting reaches a relatively low value or the production entirely ceases. At this time, and in some instances prior to any attempt to gas lift the oil, mechanical pumping devices are usually installed to lift the oil by mechanical means to the surface, these pumps usually comprising a pump barrel located at a considerable depth in the well, usually 50 to 150 feet below the surface of the liquid in the well while it is producing, plungers or other reciprocating devices being employed in the

Defendant's Exhibit Q—(Continued)

barrel and operated from the ground surface by means of sucker rods.

Usually the selection of the size and character of the pumping equipment is determined by the production of the well during its flowing or gas lifting life by estimating from this production the type or character of pump which appears to be most suitable. In many fields, however, the type, size and character of the pump installed is usually one determined as "standard for that particular type of well in the particular field. In other words, it is one having the same dimensions as pumps in other wells producing from the same horizon. Frequently, such well receives no further attention until the field as a whole has declined to a point where it becomes necessary to increase the production from the wells, as for example, by the encroachment of water necessitating the lifting of greater quantities of fluid in order to obtain the desired amount of oil. When this condition occurs, it is customary to increase the capacity of the pumping equipment.

Also, the production from a given well may be believed to be less than the character of the well and the character of the pumping equipment employed should indicate, as for example, the pump may be operating at a relatively low volumetric efficiency.

In order to determine whether or not any change in the size, character, operating characteristics or location of the pumping apparatus should be made,

Defendant's Exhibit Q—(Continued)

it is desirable that the location of the liquid surface, the character of the liquid in the well, its density and the fluid pressure at any given point below the surface of the liquid and the maximum potential production capacity of the well should be determined.

For example, if the pumps in a particular field are operating at good volumetric efficiency, much can be determined from the quantity of oil produced and the volumetric displacement per stroke of the pump, and if the pumps are operating at their maximum capacity, the fact that the fluid level is at a considerable distance above the pump inlet may indicate that the operator is justified in making a change in the size or character of the pumping equipment. Again, if the volumetric efficiency of the pump is found to be low, as for example, when the pump appears to be taking in a comparatively large quantity of gas upon each stroke of the pump, the operator should know whether or not the inlet of the pump is located at point too near the liquid surface so that he may determine how far below the liquid surface he should lower the pump in order to allow it to receive liquid for the full stroke.

Frequently in wells where the quantity of gas produced by the well is relatively small, an increased production of the pump may be obtained by raising the pump to a point nearer the liquid surface so that a better separation of the gas takes place prior to the entry of the liquid into the pump, while if the well is ~~taking~~ making a large quantity of gas,

Defendant's Exhibit Q—(Continued)

it may be better to lower the pump to a point below where the gas is separated from the liquid so that upon each stroke of the pump, dense fluid will be picked up. However, in many instances, it is dangerous to lower the pump too close to the bottom as sand is likely to be pumped into and foul the pump.

In wells where the fluid level is so low that the pump is not completely submerged and hence does not receive a full cylinder or barrel of fluid upon each stroke, a pounding at the pump is created which may be heard or determined at the ground surface. This same character of pounding, however, may be produced by the pump even though the liquid surface is at a considerable distance above the pump inlet, occasioned by the inflow into the pump of large quantities of free gas. Hence, simple tests to determine the fluid level relative to the pump inlet will not produce the desired information to the operator as to the desirable character or location of the pumping mechanism.

If, however, the fluid pressure at different levels below the surface of the fluid is determined, this information may be employed to determine the most desirable location of the pump and whether or not a change should be made in the size, operating characteristics or character of the pumping equipment employed in a given well to produce an increased or maximum production from the well.

The determination of the fluid pressure at different points below the surface of the well may be de-

Defendant's Exhibit Q—(Continued)

termined by instruments known as pressure record-
either
ers, which must be ∧ attached to ~~either~~ the pump or lowered into the well to the desired level, or must be lowered into the well on wires, cables or other supporting devices and left at the desired levels for a predetermined length of time necessary to permit the recorders to make a chart or record of the pressures encountered. All of these methods however require the stopping of the pumps and the stopping of production while the test is being made and further require the removal of the pumps and sucker rods and sometimes the tubing and other apparatus from the well in order to insert the pressure recorders or pressure measuring devices, which entails considerable labor and time and holds up the production of the well for a considerable period of time.

It is therefore an object of my invention to provide methods for determining the fluid pressure at
standing column of
any given point below the surface of the ∧ liquid in the well, determining the density of the liquid in
such column
~~the well~~ ∧ and the production index of the well without interrupting or interfering with the produc-
by the usual pumping apparatus employed therein
tion of the well ∧.

Another object of my invention is to provide a ready means for determining the fluid pressure at
of the standing column of
liquid in the well
any level below the ~~fluid~~ surface ∧ and for determining the density of the liquid in any particular well

Defendant's Exhibit Q—(Continued)

without necessitating the removal or replacement of any of the usual pumping apparatus, flow tubes, sucker rods or other mechanism found in a ~~produc-~~ being produced by a mechanical pump ~~ing~~ well ∧.

Another object of my invention is to provide information to aid in the determining of the proper location of a pump in an oil well to achieve the maximum volumetric efficiency of the pump in handling the particular character of fluid found in the particular well.

Another object of my invention is to provide a ready method for determining the potention production capacity of an oil well with a minimum of expense, delay or interruption of the production activities of the well.

Another object of my invention is to provide a ready method of determining the static fluid of pressure in oil wells without requiring the removal or replacement of any of the pumping apparatus.

Another object of my invention is to provide a ready method of determining the pressure of the fluid at any point in a well, including the entrance to the pump, by displacing the liquid by means of gas pressure down to the point where it is desired to know the fluid pressure. The normal fluid pressure existing at this point is the sum of the gas pressure at the well casing head and the pressure exerted on the liquid surface due to the weight of the gas above it.

Another object of my invention is to provide a

Defendant's Exhibit Q—(Continued)

ready means for determining the pressure of the fluid in a well at any level therein by measuring the difference in the height of the surface of the fluid under two conditions of pressure upon the surface of the fluid.

Another object of my invention is to provide a method of determining the density of the fluid in a well by measuring the amount of recession of the level of the liquid surface under two conditions of pressure upon the liquid surface and computing from the facts thus obtained the density of the fluid in the well. Fluid densities in producing wells range all the way from less than .04# per square inch to over .4# per square inch per 100 feet of fluid in the well. Therefore, a simple fluid level determination without a density or pressure determination gives very little information.

Another object of my invention is to provide a ready method for determining the potential production capacity of a well by measuring the pressure at the pump inlet under two conditions of operation of the pump and computing therefrom the maximum potentional production obtainable from the well.

Another object of my invention is to provide a ready method for determining the potential production capacity of a well by measuring the static pressure at the pump inlet and measuring the pressure at the pump inlet for at least one rate of production of the pump and computing therefrom the maximum possible production obtainable from the well.

Defendant's Exhibit Q—(Continued)

Other objects of my invention will be apparent from a study of the following specification read in connection with the accompanying drawing, wherein

Fig. 1 is a diagrammatic, cross-sectional view of a typical oil well, illustrating the level of the liquid surface as being located a considerable distance above the inlet of the pumping apparatus employed.

Fig. 2 is a view similar to Fig. 1 but illustrating the effect on the liquid surface of gas pressure allowed to build up in the casing.

Fig. 3 is a view similar to Figs. 1 and 2 illustrating the effect on the level of the liquid surface under other conditions of pressure existing within the casing of the well and illustrating the manner in which the location of the liquid surface at the pump inlet may be detected.

Fig. 4 is a diagrammatic view illustrating a chart or graph which may be employed in the practice of my method for the computation of fluid density and pressures at different locations or levels within the well.

Fig. 5 is a diagrammatic view illustrating a chart or graph which may be employed to compute the maximum potential capacity of a well from a comparison of the pressure at the pump while it is idle with the pressure at the pump while it is operating normally.

Defendant's Exhibit Q—(Continued)

Fig. 6 is a view similar to Fig. 5 illustrating the manner in which a more accurate computation of the potential capacity of a well may be obtained by comparing the pressure at the pump under two production rates of the pumping apparatus.

Referring to the drawings, I have illustrated in Fig. 1 a typical oil well which includes a casing 1 extending down through the well bore from the ground surface 2 into the oil producing sands, the oil flowing from the sands or oil formation into the casing and rising in the casing to some level indicated at 3. Pumping apparatus employed to remove the oil from the well usually includes a suitable pump 4 located upon tubing string 5, constituting the flow tubing through which the oil is raised to the ground surface, the pump 4 including usually some reciprocating mechanism operated by reciprocal movements of a string of sucker rods 6 extending down through the tubing 5 and connected to reciprocating power apparatus at the ground surface, as indicated at 7. The flow tubing 5 is provided with an outlet 8 communicating with a suitable oil line through which the oil pumped from the well is conveyed to any desired location.

The casing 1 is closed at its upper end as indicated at 9, an outlet being provided communicating with the casing 1 to permit gas escaping from the oil to pass into a suitable gas line 11, a control valve 12 being usually provided to control the flow of gas into the gas line.

Defendant's Exhibit Q—(Continued)

By properly selecting the size, the stroke and the speed of the pump 4, the pump may be made to remove the oil from the well at approximately the same rate at which the oil flows into the well from the surrounding formation, and if so selected, the well will be operated at its maximum capacity. However, oil coming from the formation contains relatively large quantities of gas which, due to the pressure of the oil, cannot readily escape but which when the oil enters the pump tends to expand in the pump, reducing the volumetric efficiency of the pump. If now the pump is so located relative to the liquid surface that the greater portion of the gas within the well has been permitted to escape prior to the entry of the oil into the pump, it follows that upon each stroke of the pump, the pump will be operated upon relatively dense fluid and will hence operate at relatively high volumetric efficiency.

I have discovered ready means for determining not only the pressure existing at the pump without requiring the removal of the pump or any of its apparatus but also I have discovered a ready method for determining the density of the fluid at the pump entrance, the information so obtained being used in the location of the pump at the most desirable level to obtain the maximum volumetric efficiency of the pump.

To obtain the information required, I measure or determine the stable location of the liquid surface

Defendant's Exhibit Q—(Continued)

of the "standing column" of liquid within the well ∧ when the pump is operating at its normal production capacity and with the pressure of gas within the casing at the usual or normal value maintained during the usual or normal pumping operations at the well. (∧ D^2) This location of the fluid level may be readily accomplished by employing the methods and apparatus disclosed in United States Letters Patent No. 2,047,974 issued to Harold T. Wyatt and Paul E. Lehr, July 21, 1936, and in my copending applications Serial No. 162,699 filed September 7, 1937, and Serial No. 164,534 filed September 18, 1937. While the methods and apparatus are completely disclosed in the said patent and applications, the method may be stated briefly as including

annular space between the tubing 5 and the

the introduction into the ∧ well casing of a sudden change in pressure in the well casing and measuring the length of time elapsing between the production of this pressure impulse and the return to the ground surface of the echo thereof from the surface of the fluid. By noting the distance from the ground surface of the fluid level under these conditions and by noting the pressure of gas at the casing head, as by means of a pressure gauge 13,

∧ the pressure on the liquid surface may be computed as follows: To the casing head pressure is added the effect of pressure on the liquid surface exerted by the weight of the column of gas between the liquid surface and the casing head. A

Defendant's Exhibit Q—(Continued)

gravity test may be made of the gas at the casing head which will determine the pressure exerted by each foot or hundred feet of height of the gas column. This information may be computed by the following formula which is by Dice:

$$\text{Log}_{10}\text{Pb} = \frac{\text{SD}}{122.82\text{T}} + \text{Log}_{10}\text{Pt}$$

Where

Pb = Lbs/sq. in. absolute at bottom of gas column.

Pt = Lbs/sq. in. absolute at top of gas column.

S = Specific gravity of the gas (air is considered 1).

D = Depth from casing head to liquid surface.

T = Mean temp. of the gas column in degrees F absolute.

This information may then be plotted upon a graph or chart as illustrated in Fig. 4 in which the conditions existing in the particular well under measurement are assumed to be such that with a pressure of 36 pounds per square inch at the casing head, the liquid surface is found to lie at 3100′ below the casing head. The specific gravity of the gas in this instance may be found to be such that the effect will be to produce 4 pounds per square inch pressure on the liquid surface. Thus, the addition of 36 pounds and 4 pounds produces a total pressure on the liquid surface of 40 pounds per square inch. By arranging the chart shown in Fig. 4 with the ordinates representing the fluid level measured from the ground surface and the abscissae representing pres-

Defendant's Exhibit Q—(Continued)

sure on the liquid surface in pounds per square inch, the point L1 determined from the preceding formula may be plotted on the chart shown in Fig. 4.

Now, the valve 12 is closed or a suitable pressure regulator is placed in the gas line 11 and the pressure within the casing is allowed to build up to any predetermined value. As the pressure builds up, the oil level 3 tends to recede. By continuing the operations of the pump during the building up of this pressure, preferably for a period substantially equal to the time required for the pump to remove the column of fluid between the original fluid level and a new fluid level to which the pressure depresses the liquid surface, represented at 3a (Fig. 2) multiplied by 3, it will be found that a stable condition will be achieved at which the fluid level will become constant and the production by the pump will be approximately the same as before the pressure was allowed to build up in the casing. When this stable condition is reached, a second measurement of the fluid level is obtained by the level measuring methods and apparatus hereinbefore described.

Having determined the new location of the liquid surface, the pressure exerted thereon may now be calculated as follows: Assuming that the casing head pressure in this instance was adjusted to 170 pounds, to this should be added the pressure due to the weight of the column of gas above the new fluid level. The determination of the effect of the

Defendant's Exhibit Q—(Continued)

weight of the column of gas upon the fluid level may be obtained either by calculation or may be plotted out and obtained from suitable charts prepared for this purpose. In this instance, it may be assumed that the pressure due to the gas column is 30 pounds per square inch, making a total of 200 pounds per square inch on the fluid. Now, assuming that the level to which the ∧ ~~fluid~~ has receded is 3966′ from the top of the well, the new point L2 shown in Fig. on the chart ∧ 4 representing the new level and the pressure on the liquid surface may be placed upon the chart. From an exhaustive series of actual tests, it has been discovered that the relation between the pressure on the liquid surface and the distance through which the fluid will recede in any given well having a uniform cross-sectional area is Shown in Fig. constant, so that a line drawn on the chart ∧ 4 intersecting the points L1 and L2 will truly represent the fluid level at any of the pressure ∧ s which may be placed upon the fluid column. Thus, by merely extending the line C downwardly on the chart until it crosses the ordinate representing the location of the pump inlet indicated on the chart as A, a direct reading of the fluid pressure required to cause the surface of the column to recede to the pump inlet is obtained. On the chart this is represented as 336 pounds per square inch, which is the

Defendant's Exhibit Q—(Continued)

pressure at the pump for the normal rate of production, assuming that the rate of production was normal during the tests.

The actual pressure in the column of ∧ ~~oil~~ liquid at the pump inlet may, however, be calculated from the information received by the two fluid level tests described above. That is, by subtracting the original fluid level from the new fluid level, the total difference in the level will be found in this instance 866'. Then, by subtracting the original pressure on the liquid surface from the new pressure on the liquid surface, a difference of 160 pounds per square inch is found to have been necessary to cause the ∧ ~~fluid~~ liquid column to recede 866'. By dividing the difference in fluid pressure by the difference in surface level, the density of the ∧ ~~oil~~ liquid mixture of oil and gas in the well ($\wedge D^4$) may be found. In this instance, the column receded a distance between 3100' and 3966' or a total distance of 866', while the pressure difference is 160 pounds. The density of the ∧ ~~oil~~ liquid is such therefore as to exert 0.185 pounds per square inch per foot of height of the column.

Hence, knowing the pressure on the fluid surface at any level thereof and knowing the distance below this surface at which the pump inlet is located, a direct calculation of the fluid pressure at the pump inlet may be obtained by the following formulae:

The pressure at any point below the normal fluid

Defendant's Exhibit Q—(Continued)

level in a well at which the level can be maintained by means of gas pressure in the casing is PL1 = Pc1 + Pg1 and PL2 = Pc2 + Pg2. The density of the fluid for the rate of production during the tests is

$$D = \frac{PL2 - PL1}{L2 - L1}$$ = density of the fluid in lbs. per sq. in. per ft. of fluid.

The pressure at the pump is Pa = D(La—L2) + PL2 where

Pc1=gage casing pressure to maintain fluid at level L1.

Pc2=gage casing pressure to maintain fluid at level L2.

Pg1=pressure exerted upon fluid surface by weight of gas above it at level L1.

Pg2=ditto for level L2.

PL1=pressure on the fluid surface at level L1.

PL2=pressure on the fluid surface at level L2.

L1 =fluid level corresponding to Pc1.

L2 =fluid level corresponding to Pc2.

La =pump location in feet from ground surface.

Pa =pressure at the pump.

In the example shown in Fig. 4, assuming the inlet to the pump is located at the 4700′ level, the pressure of the oil at this point would be equal the sum of the gas pressure at the casing head for level L2, the pressure exerted by the column of gas above liquid the ∧ ~~fluid~~ surface corresponding to this level and the pressure exerted by the column of oil above the

Defendant's Exhibit Q—(Continued)

pump inlet. In this instance, the pressure at the casing head is assumed to be 170 pounds per square inch, the effect of the column of gas at this pressure with the fluid level at 3966′ from the surface being 30 pounds per square inch and the effect of the column of liquid above the pump inlet being 734′ at .185 pounds per square inch per foot, or 135.5 pounds per square inch exerted by the column of liquid, the result being 335.5 pounds per square inch pressure at the pump entrance. This result is clearly illustrated in Fig. 4 by the point A, the point A being located at the 335.5 pound mark on the abscissae of the chart. If desired, an estimation of the bottom hole pressure may also be made by continuing the line C downwardly on the chart to intersect the ordinate representing the bottom of the well, such point being indicated at B, or the pressure at any other level in the well below the surface of the ~~fluid~~ liquid for the rate of production at which the tests were made may be located along the line C. ($\wedge D^5$)

Knowing the density of the oil and the pressure exerted at the pump inlet, the operator of any particular well may determine whether or not it is practicable to increase the amount of fluid being produced. If the volumetric efficiency of the pump is low and the tests indicate considerable pressure at the pump, he may raise the pump to a level indicated upon the line C at which better separation of gas will usually occur prior to entry of fluid into the pump.

Defendant's Exhibit Q—(Continued)

The utilization of the information obtained by the foregoing method will also accurately produce the information of the maximum potential production of the well as by comparing the pressure of the fluid at the pump under two or more different operating conditions of the pump. For example, the static fluid pressure at the pump when the pump is not operating may be measured and compared with the fluid pressure at the pump when the pump is operating at its normal rate of production or at any other rate of production; a comparison of the two values so obtained will produce a constant indicating the ratio between the potential production and pressure at the pump inlet, so that by employing this constant at a theoretical zero pump inlet pressure (which would represent the fluid being removed from the well at the rate it flows into the well from the formation) the maximum potential capacity of the well may be found.

Employing the method of determining fluid pressure at the pump hereinbefore described, the static liquid pressure may be readily obtained without necessitating the use of pressure recorders or other devices requiring the removal of or alteration of any of the pumping mechanism and the measurement may be made in wells which have been shut down as readily as in wells which are actively producing.

To obtain the fluid pressure at any point at or below the liquid surface when the well is not producing fluid, the casing should be closed in and the gas escaping from the liquid should be allowed to build

Defendant's Exhibit Q—(Continued)

up pressure in the casing until a suitable condition is reached, that is, a point is reached at which no more gas is made by the well (no more gas escapes from the liquid). When this point is reached, the remaining fluid in the well may be considered as dense fluid.

Now, by determining the height of the liquid surface under these conditions by my method, the pressure on the liquid surface may be readily determined and by adding thereto the effect of the weight of the column of fluid above any given level, the fluid pressure at that level may be found. This information alone is extremely useful to the operators of producing wells.

The information thus obtained may be plotted on a graph or chart such as that shown in Fig. 5, wherein the ordinates represent fluid pressure at the pump inlet in pounds per square inch and the abscissae represent rate of production of oil from the particular well under consideration, and the static pressure may be plotted at zero production, as indicated by the point D in Fig. 5.

The casing pressure may now be reduced and the pump started and allowed to assume a predetermined rate of production, preferably its normal rate. Assuming this rate is 200 barrels of oil per day, a new determination of the fluid pressure at the pump is made at this rate of production. That is, the pump is started and allowed to operate until the fluid level in the well reaches a stable condition. The location of the fluid level, the pressure in pounds per

Defendant's Exhibit Q—(Continued)

square inch at the pump inlet under these conditions is determined by the method hereinbefore described and the fluid pressure at the pump is plotted against the production rate on the chart shown in Fig. 5. Assuming that this new pressure at 200 barrels per day is found to be at the point indicated in Fig. 5 at E, a straight line drawn between the points D and E will intersect the zero pressure ordinate at a point representing the maximum potential capacity of the well. In the diagram shown in Fig. 5, this maximum potential production capacity is found to be 300 barrels per day. In other words, if a pump of sufficient capacity is installed in this well and operated in such manner as to remove 300 barrels per day, the oil will be removed at the same rate at which it flows into the well from the formation.

A more accurate determination of the maximum potential production capacity of the well may be made by comparing the fluid pressure at the pump under two different operating conditions of the pump, such as by measuring the fluid pressure at the pump when the pump is operating at one production rate, for example its normal rate, and then changing the rate of production of the pump as by slowing the pump down, changing the stroke of the pump or by building up gas pressure on the liquid surface and plotting the relation between the new production rate and the fluid pressure measured by my method, as set forth herein, it will be found that a line intersecting these two points will also repre-

Defendant's Exhibit Q—(Continued)

sent the relation between production rate and fluid pressure at the pump at any rate of production by the pump. As shown in Fig. 6, the normal production rate of 200 barrels per day plotted against the fluid pressure at the pump in pounds per square inch may be represented upon the chart by the point G while at a reduced rate of production at the pump, say to 100 barrels per day, it will be found that the fluid pressure at the pump is increased so that by determining the fluid pressure under these conditions, the relation between the reduced production rate and the fluid pressure at the pump may be plotted by the point H. A straight line interconnecting the points H and G will intersect the zero pressure ordinate at a point therealong, indicating a maximum possible production of 300 barrels per day. In making such determinations, however, it is desirable that the rate of production of the pump be reduced to at least two thirds of its normal production rate and preferably to 50% of its normal production rate in order to obtain substantially widely separated points H and G.

Again, it will be noted that all of the necessary calculations to determine the maximum production possible of the well may be made without interrupting the normal production conditions at the well and without requiring the laborious efforts of removing and replacing any of the pump mechanisms.

In order to determine the fluid pressure at the pump in most producing wells where there is considerable fluid over the pump one, two or more fluid

Defendant's Exhibit Q—(Continued)

level measurements are made by the method described and claimed in the Wyatt et al. patent and in my co-pending applications hereinbefore referred to, from which level determinations the pressure at the pump is determined as described hereinbefore. However, I have discovered that in some wells where the operating fluid level is some distance above the pump and where there is sufficient gas pressure to depress the fluid level to the pump, the pump, when the fluid level reaches or approaches its inlet, will produce a pressure wave and this pressure wave may be detected by a skilled operator by employing either the mechanical or electrical vibration receiving and translating mechanism illustrated in my co-pending applications hereinbefore referred to, the electrical system being illustrated diagrammatically in Fig. 3, wherein a microphone 15 is coupled to the gas outlet pipe 11 to be actuated or vibrated in accordance with pressure waves passing upwardly in the casing 1. The microphone 15 is illustrated as a diaphragm condenser type microphone coupled through a detector-amplifier system 16, the output of which is connected to a galvanometer 17 to move a mirror 18 in accordance with movement of the microphone 15 to reflect a light beam 19 from a suitable source of light 20 upon a screen 21 to describe on the screen a line of light the length of which corresponds to the amplitude of the pressure waves received upon the diaphragm 15.

When the fluid surface is well above the pump there will be observed a regular wavy pulsation of

Defendant's Exhibit Q—(Continued)

the light on the screen but when the level of the fluid is so depressed that the pump takes in a quantity of free gas on each stroke a jerky motion is observed.

Thus, by observing the screen 21, a skilled operator is able to distinguish between fluid surface pulsations caused by the action of the pump and pressure waves produced by the pump when the level of the fluid reaches the pump inlet.

While the pressure waves created at the pump under these conditions may be visually observed with the light beam and screen arrangement shown in Fig. 3, they may be equally as well observed audibly by employing a telephone receiver 22 or other audible translating device coupled to the output circuit shown and described in my co-pending application Serial No. 164,534 herein. By listening at the receiver, a skilled operator may determine the "break" or change of pressure waves occasioned by the level of the liquid approaching the pump inlet.

While a diaphragm type of microphone is shown in Fig. 3, a hot-wire, ribbon or other types of microphones may also be used.

Having this means of knowing when the liquid level is at or near the pump the casing pressure is adjusted to maintain the liquid level a few feet above the pump inlet until the rate of production becomes constant under the increased casing pressure. From the casing pressure required to maintain the liquid level close to the pump the pressure at this level can be determined by adding to the casing pressure the

Defendant's Exhibit Q—(Continued)

pressure on the liquid surface caused by the weight of the gas column above it. (∧C1)

Pump noises at the ground surface have been heard or observed as accompanying a low volumetric efficiency of the pump, indicating that charges of free gas are entering the pump on each stroke. However, it has heretofore been impossible to distinguish between the two conditions which caused them, namely whether the liquid level was so low as to fall to or below the pump inlet on each stroke or whether the pump inlet was located well below the surface but at such point in the liquid column that free gas was entering the pump with the liquid. By employing my method of detecting the waves and then determining the level of the fluid surface, these may readily be distinguished and the pump raised or lowered as is indicated as necessary to correct the trouble.

It will therefore be observed that I have provided a ready method for determining the density of the fluid in any particular well and also for the determination of the fluid pressure at the pump without requiring the removal or alteration of any of the usual mechanism found in the well. It will also be noted that I have provided a ready method for graphically determining the fluid pressure at the pump by first determining the amount of recession of the fluid level due to changes in gas pressure exerted upon the fluid surface and plotting this information upon a graph or chart and extending a straight line intersecting the two or more points so

Defendant's Exhibit Q—(Continued)

located to a point on the chart representing the level of the pump inlet. It will also be noted that I have devised a ready means of utilizing the information obtained with respect to fluid levels and gas pressures at the casing head of the pump for mathematically determining the fluid pressure at the pump and also for utilizing this information to determine accurately the potential production of any well measured. (∧C2)

While I have illustrated and described the preferred embodiment of my invention, I do not desire to be limited to any of the detail illustrated or described herein except as defined in the appended claims.

HWM:SG

I Claim

1. The method of determining the pressure of liquid in a well at the level of the liquid surface therein, which consists in determining the location of the liquid surface and adding to the pressure of the gas at the casing head, the effect in pressure of the column of gas between the liquid surface and the casing head.

2. The method of determining the pressure of liquid in a well at any desired level therein, which consists in changing the pressure of gas on the liquid surface to move the surface to the desired level and adding the pressure at the casing head of the gas required to so located the surface to the effect in pressure of the column of gas between the liquid surface and the casing head.

Defendant's Exhibit Q—(Continued)

3. The method of determining the pressure of liquid in a well at any level below the surface thereof, which consists in allowing the level of the liquid surface to become stable, measuring the location of the liquid surface under stable level condition, noting the pressure of gas upon the liquid surface and computing the desired pressure by adding the gas pressure at the casing head of the well to the effect in pressure of the column of gas between the liquid surface and the casing head and adding the effect in pressure of the column of fluid above the desired level.

4. The method of determining the pressure of liquid in a well at any desired level at or below the surface of the liquid therein, which consists in building up and maintaining gas pressure within the casing of the well until the liquid surface level therein becomes stable, measuring the location of the liquid surface under this stable condition and computing the desired pressure by adding the gas pressure at the casing head of the well to the effect in pressure of the column of gas between the liquid surface and the casing head and adding thereto the effect in pressure due to the column of liquid between the liquid surface and the desired level.

5. The method of determining the pressure of liquid in a well at any level therein at or below the liquid surface while the pump ~~pipe~~ is producing liquid from the well, which consists in allowing the level ~~of the liquid surface to become stable under the pro-~~

Defendant's Exhibit Q—(Continued)

duction rate of the pump, measuring the location of the stable surface level and computing the desired pressure by adding the gas pressure at the casing head of the well to the effect in pressure of the column of gas between the casing head and the liquid surface and adding thereto the effect in pressure of the column of fluid between the stable liquid surface level and the desired level.

6. The method of determining the pressure exerted by the liquid in a well at any level therein, which consists in measuring the stable liquid level in one known condition of gas pressure in the casing of the well, determining the stable level of the liquid in the well under another known condition of gas pressure within the casing of the well, plotting the relations between liquid level and pressure on the liquid surface, extending a straight line intersecting said plotted points and determining the pressure at any level by points on said line representing said desired level.

7. The method of determining the pressure exerted by the liquid in a well at any point below the surface of the liquid which consists in determining the stable level of the liquid under one known condition of pressure of gas within the casing of the well, determining the stable level of the liquid under another known condition of gas pressure within the casing of the well, determining the pressure exerted by the liquid per unit of height of the liquid by comparing the difference in said levels with the difference in pressure required to change said levels

Defendant's Exhibit Q—(Continued)

and adding to the pressure upon the surface of the liquid at either of said levels the product of the height of the surface above the desired level by the unit of pressure so obtained.

8. The method of determining the pressure of liquid in a well at the level of the inlet of a pump in said well which consists in measuring the stable level of the liquid surface under one condition of gas pressure in the casing of the well, measuring the stable level of the surface of the liquid in the well under a different condition of gas pressure in the casing of the well, computing the density of the liquid in the well by dividing the increase in pressure by the distance between the two levels of the surface of the liquid so determined and then adding the sum of the gas pressure in the casing and the pressure exerted by the weight of the column of gas above the liquid surface at one level to the product of the distance between the liquid surface level and the level of the pump inlet and the density of the fluid so obtained.

9. The method of determining the pressure exerted by the liquid in a producing well at any desired level below the level of the surface of the liquid, which consists in plotting the relation between two stable levels of the liquid surface against the stable pressures on the liquid surfaces required to maintain said levels, extending a straight line from said plotted points and determining the pressure at the desired level from the intersection of said line with a plot of the desired level.

Defendant's Exhibit Q—(Continued)

10. The method of determining the pressure of liquid in a producing well at the level of the inlet of a pump therein which consists in building up just the proper amount of gas pressure in the well casing to maintain the liquid level at or preferably a few ^ feet above the level of the pump inlet and computing the desired pressure by adding the gas pressure at the casing head of the well to the effect in pressure of the column of gas between the pump inlet and the casing head.

11. The method of determining the pressure of liquid in a producing well at the level of the inlet of a pump in said well, which consists in depressing the surface of the liquid from its normal level to the level of the pump inlet by gas pressure in the casing of the well and while the pump is operating, determining the arrival of the surface of the liquid at the level of the pump inlet by detecting visually or audibly pressure waves produced by the pump when the level reaches its inlet and then, after the pump has operated a sufficient length of time for all conditions to become stable, computing the pressure at the pump by adding the pressure of the gas at the casing head required to maintain the liquid level at or near the inlet of the pump, to the effect in pressure due to the column of gas between the pump inlet and the casing head.

12. The method of determining when the surface of the liquid in a well is at the level of the pump inlet, which consists in observing the pressure waves

Defendant's Exhibit Q—(Continued)

produced at the pump by the entry of free gas thereto.

13. The method of determining when the surface of the liquid in a producing well is at the level of the pump inlet, which consists in observing the difference in the pressure waves produced in the gas in the casing by the surge of the liquid level caused by removal of liquid by the pump and those waves produced by the entry of free gas into the pump.

14. The method of determining when the surface of the liquid in a producing well is at the level of the pump inlet, which consists in visibly observing the difference in the pressure waves produced in the gas in the casing by the surge of the liquid level caused by removal of liquid by the pump and those waves produced by the entry of free gas into the pump.

15. The method of determining when the surface of the liquid in a producing well is at the level of the pump inlet, which consists in audibly observing the difference in the pressure waves produced in the gas in the casing by the surge of the liquid level caused by removal of liquid by the pump and those waves produced by the entry of free gas into the pump.

16. The method of determining when the surface of the liquid in a producing well is at the level of the pump inlet, which consists in exposing a microphone to the gas in the well casing and observing the difference in the effect upon the microphone under

Defendant's Exhibit Q—(Continued)

~~pressure waves created in the gas by the surge of the~~ liquid level in the well caused by removal of liquid by the pump and those waves produced by the entry of free gas into the pump.

17. The method of determining when the surface of the liquid in a producing well is at the level of the pump inlet, which consists in exposing a diaphragm to the gas in the well casing and observing the difference in the movement of the diaphragm under pressure waves created in the gas by the surge of the liquid level in the well caused by removal of liquid by the pump and those waves produced by the entry of free gas into the pump.

18. The method of determining the static pressure at the inlet of the pump in a well, which consists in closing the casing of the well ∧ ~~to allow~~ and building up the pressure of the gas within the well to depress the level of the liquid therein to a stable level and then locating the stable level of the liquid surface.

19. The method of determining the static pressure at the inlet of the pump in a well, which consists in closing the casing of the well ∧ ~~to allow~~ and building up the pressure of the gas within the well to depress the level of the liquid therein to a stable level, locating the stable level of the liquid surface, and then computing the pressure at the pump inlet by adding to the pressure of the gas at the casing head the effect in pressure of the column of gas between the casing head and the liquid surface and adding thereto the effect in pres-

Defendant's Exhibit Q—(Continued)

sure of the column of liquid between the surface level so determined and the level of the pump inlet.

20. The method of determining the static pressure at any level below the liquid surface of a well, which consists in closing the casing of the well and building up the pressure of ^ ~~to allow~~ the gas within the well to depress the level of the liquid therein to a stable level, locating the stable level of the liquid surface, and then computing the pressure at the desired level by adding to the pressure of the gas at the casing head the effect in pressure of the column of gas between the casing head and the liquid surface and adding thereto the effect in pressure of the column of liquid between the surface level so determined and the level so desired.

21. The method of determining the maximum potential capacity of an oil well which consists in determining the pressure of the liquid at the pump inlet while the pump is operating at one rate of production, by locating the stable level of the surface of the liquid under one condition of gas pressure at the casing head, adding to the pressure at the casing head the effect in pressure of the column of gas between the casing head and the liquid surface, determining the density of the liquid for this rate of production and adding to the sum of the pressures obtained, the effect in pressure of the column of liquid between the liquid surface and the pump inlet, then changing the rate of production and depressing the liquid surface to a point so near to the pump in-

Defendant's Exhibit Q—(Continued)

~~let that the determination of density of liquid under~~ this pressure and rate of production is unnecessary, adding to the pressure of the gas required to so depress the liquid level the effect in pressure of the column of gas between the pump inlet and the casing head, and then comparing the change in production with the change in liquid pressures at the pump inlet and using the ratio thus found to determine the date of production for zero, or any other pressure, at the pump or at other locations normally below the producing level of the liquid in the well.

22. The method of determining the potential production capacity of an oil well, which consists in determining the static or non-producing pressure of the liquid at the pump inlet by closing the casing head, allowing the pressure of the gas escaping from the fluid to depress the surface level of the liquid to a stable condition, locating this level and computing from the pressure at the casing head and the liquid surface level, the pressure at the pump inlet, determining the pressure at the pump inlet when the pump is operating at a predetermined production rate by locating the liquid surface level when the pump is so operating and computing from the pressure of the gas at the casing head and the second level so obtained, the second pressure of the liquid at the pump inlet and comparing the two pressures of the liquid at the pump inlet to determine the production capacity of the well at zero pressure of the liquid.

Defendant's Exhibit Q—(Continued)

23. The method of determining the potential production capacity of an oil well, ($\wedge C^7$) which consists in determining the static, or non-producing pressure of the liquid at the pump or at any other desired location near the bottom of the well by closing the casing head, allowing the pressure of the gas escaping from the liquid to depress the surface level of the liquid to a stable condition, locating this level and from the known gas and fluid gravities and the pressure at the casing head computing the pressure at the pump inlet or other location near the bottom of the well; determining the pressure at the pump inlet or other location near the well bottom at a predetermined production rate by locating the liquid surface level when the pump is so operating, adding to the pressure at the casing head the effect in pressure of the column of gas between the casing head and the liquid surface, determining the density of the liquid for this rate of production and adding to the sum of the pressures obtained, the effect in pressure of the column of liquid between the liquid surface as determined and the pump inlet or other location near the bottom of the well, comparing the difference between the static and operating pressures so determined at the pump, or other location near the bottom of the well, with the operating rate of production for the test and using the ratio thus found to determine the production capacity for zero, or any other pressure at the pump inlet or at other locations normally below the producing level of the liquid in the well.

Defendant's Exhibit Q—(Continued)

24. The method of determining the potential production capacity of an oil well, ($\wedge C^7$) which consists in determining the pressure of the liquid at the pump inlet or other location near the bottom of the well while the pump is operating at one rate of production by locating the stable level of the liquid surface under one condition of gas pressure at the casing head, adding to the pressure at the casing head the effect in pressure of the column of gas between the casing head and the liquid surface, determining the density of the liquid for this rate of production and adding to the sum of the pressures obtained the effect in pressure of the column of liquid between the liquid surface and the pump inlet or other location near the bottom of the well; changing the rate of production by altering the speed of operation of the pump, the length of the pump plunger stroke, or by changing the casing pressure, then repeating the operations and calculations made for determining the pressure at the pump or other location near the bottom of the well for the first rate of productions; then comparing the change in production with the change in liquid pressure at the pump inlet or other location near the bottom of the well and using the ratio thus found to determine the rate of production for zero, or any other pressure, at the pump inlet or at other locations normally below the producing level of the liquid in the well.

25. The method of determining the potential production capacity of an oil well, ($\wedge C^8$) which con-

Defendant's Exhibit Q—(Continued)

sits in determining the liquid pressure at or near the pump inlet when the pump is operating at its normal or any other rate of production, reducing the production rate of the pump by increasing the gas pressure in the casing to depress the liquid level until the liquid surface level attains a suitable condition adjacent the inlet of the pump, computing the pressure on the surface of the liquid at the new level and comparing the change in production with the change in liquid pressures at the pump inlet and using the ratio thus found to determine the rate of production for zero, or any other pressure at the pump or at other locations normally below the producing level of the liquid in the well.

26. The method of determining the density of liquid in a well (∧C9) which consists in measuring annular space between the pump tubing and the casing the fluid level in the ∧ ~~well~~ under one condition of gas pressure in the well, changing the gas pressure in the well and measuring the stable fluid level under the new gas pressure conditions and comparing the on the liquid surface increase in pressure ∧ with the change in fluid level.

27. The method of determining the density of liquid in a well (∧C9) which consists in measuring annular space between the pump tubing and the casing the level of the surface of the liquid in the ∧ ~~well~~ under one condition of gas pressure in the well, depressing the fluid level to a new location by changing the pressure of the gas in the well and compar-

Defendant's Exhibit Q—(Continued)

~~on the liquid surface~~

ing the increase in pressure ∧ required to achieve the new stable level with the difference in stable levels of the liquid surafce.

28. The method of determining the density of the liquid in a well (∧C10) which consists in deter-

annular space between the
pump tubing and the casing

mining the liquid level in the ∧ ~~well~~ under one condition of pressure, changing the pressure of the gas within the well to move the liquid surface to a new stable level, measuring the new level and dividing the change in pressure on the fluid surface to achieve the new level by the difference between the two levels.

29. The method of determining the density of liquid in a well (∧C10) which consists in measuring

annular space between the
pump tubing and the casing

the fluid level in the ~~well~~ ∧ while the pump therein is operating under a known condition of gas pressure on the surface of the liquid in the well, changing the gas pressure on the liquid surface in the well, continuing the operation of the pump until the liquid level therein becomes stable at a new location and comparing the difference in the pressures exerted on the liquid surface at the two levels with the difference in feet of the two levels.

30. The method of determining the density of fluid in a well (∧C10) which consists in employing the gas produced in the well to hold the liquid sur-

Defendant's Exhibit Q—(Continued)

face in the ∧ ~~well~~ annular space between the pump tubing and the casing at two different levels and comparing the difference in the pressures exerted by the gas on the liquid surface at the two levels with the difference in feet between the two levels.

31. The method of determining the density of liquid in a well (∧C11) which consists in measuring the level of the surface of the liquid under one condition of pressure of the gas released by the well, regulating the flow of gas from the well to increase the pressure of said gas to a different value and comparing the difference in the pressures exerted upon the liquid surface under the two conditions of gas pressure with the difference in feet of the levels of the liquid surface under the two pressure conditions.

32. The method of determining the density of liquid in a well (∧C11) while it is producing normally, which consists in depressing the level of the surface of the liquid to two or more known stable locations, determining the stable pressure on the liquid surface at the two locations and comparing the difference in feet between any two levels with the pressure required to change the liquid level from one location to the other.

33. The method of determining the density of liquid in a well (∧C12) which consists in determining the stable level of the liquid in the ∧ ~~well~~ annular space between the pump tubing and the casing under one stable condition of gas pressure in the casing

Defendant's Exhibit Q—(Continued)

~~of the well, depressing or elevating the liquid level~~ in the well by increasing or decreasing the pressure of the gas within the casing of the well, determining the new stable liquid level and then comparing the difference between the difference between the two stable levels with the pressures exerted on the liquid surface by the gas under the two stable pressure conditions.

34. The methods of determining the density of the liquid, the liquid pressure at any level and the maximum potential production capacity in an oil ~~well substantially as shown and described herein.~~

In Testimony Whereof I affix my Signature
(Sign here first name in full)

CRANFORD P. WALKER.

OATH

State of California,
County of Los Angeles—ss:

Cranford P. Walker, the above named petitioner, being duly sworn, deposes and says that he is a citizen of the United States, and resident of San Marino, California; that he verily believes himself to be the original, first and sole inventor or discoverer of the Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells described and claimed in the annexed specifications; that he does not know and does not believe that the same was ever known or used before his invention

Defendant's Exhibit Q—(Continued)

or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this application; that said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months prior to this application; and that no application for patent on said invention has been filed by him or his legal representatives or assigns in any country foreign to the United States.

(Sign here, first name in full)

CRANFORD P. WALKER.

Subscribed and sworn to before me, this 20th day of October, 1937.

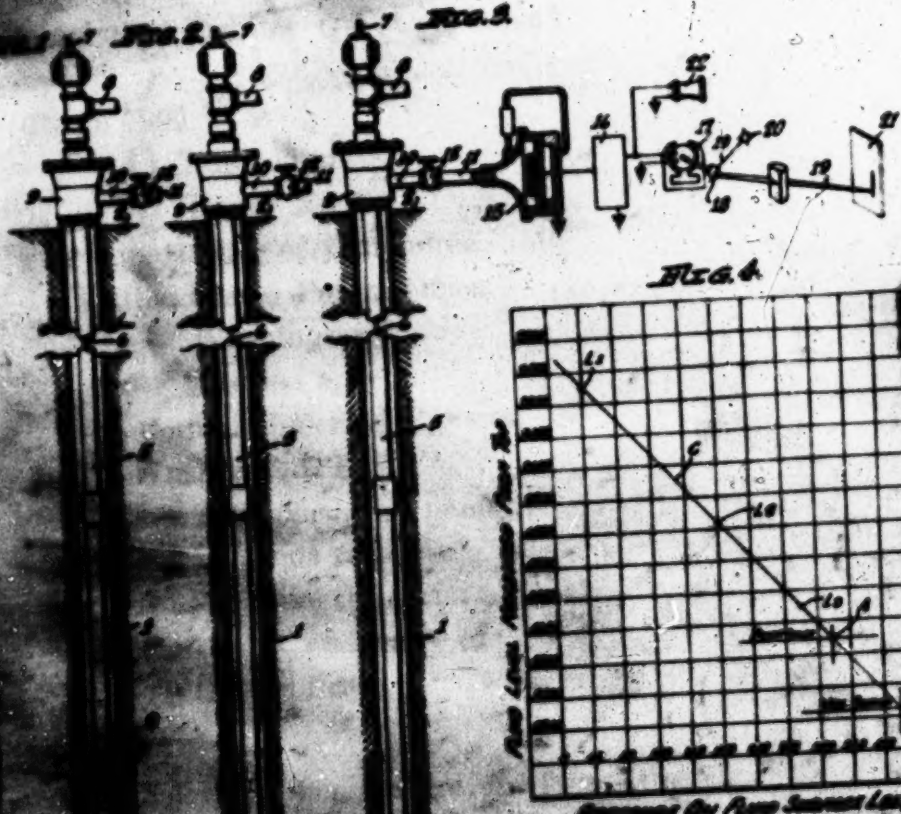
(Seal) } MARJORIE McKAY,

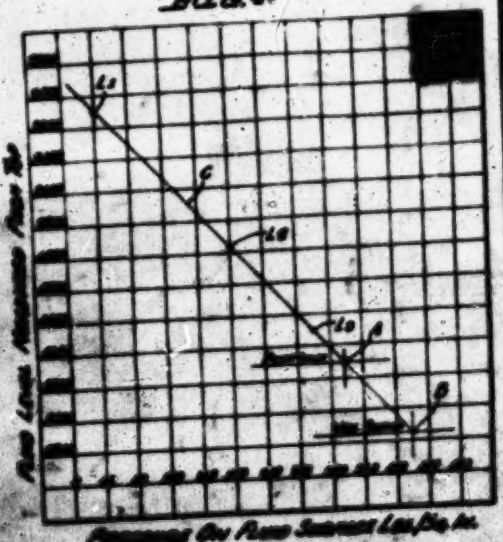
Notary Public in and for said County and State.

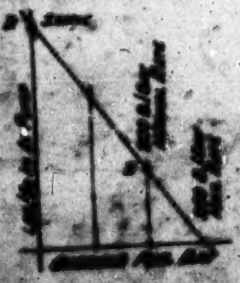
My Commission Expires July 14, 1941.

171170

Print of drawing as originally filed.







INVENTOR:

ATTORNEY.

42R

171170

Defendant's Exhibit Q—(Continued)

260

Div. 36 Room 7892

Buchler:mwc
Paper No. 3
Department of Commerce
United States Patent Office
Washington
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name
All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Mailed Feb 5 1938.

Please find below a communication from the EXAMINER in charge of this application.

CONWAY P. COE
Commissioner of Patents,

Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope St.,
Los Angeles, California.

Applicant: Cranford P. Walker
Ser. No. 171170
Filed Oct. 26, 1937
For Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

Defendant's Exhibit Q—(Continued)

This application has been examined.

The following references, the result of a cursory search, are cited to show classification of the groups of the requirement for division stated below:

Lehmann,	1,960,158,	May 22, 1934,	(73-31-6);
et al,	3,047,974,	July 21, 1936,	(177-352.6);
Doherty,	1,899,497,	Feb. 28, 1933,	(166-21);
Hay,	2,056,187,	Oct. 6, 1936,	(265-44);

How does Applicant know that the lines connecting points D and E in Fig. 5 and the line connecting points G and H in Fig. 6 will be straight lines? For instance, Figs. 5 and 6 indicate that, at zero pressure at the pump inlet, the capacity is 300 barrels per day. Assuming the pump to be pumping 300 barrels per day, it would seem that there would be a substantial pressure at the pump inlet due to the gas pressure in the well. Thus, it would seem that line DE or HG would never intersect the zero pressure line.

In Fig. 3, is not casing 1 shown as being sealed from the oil below the pump? If so, how may oil rise in casing 1?

In line 21 of page 2, "any" should be <u>may</u>.

In line 12 of page 14, "pressure" should apparently be pluralized.

Apparently the comma in line 24 of page 17 should be a semi-colon.

In line 8 of page 19, <u>and</u> should be inserted before "the".

Claims 1 to 34, inclusive, are in the case.

The claims are drawn to four distinct and independent inventions. Thus:

Defendant's Exhibit Q—(Continued)

I. Claims 1 to 11, both inclusive, 18, 19 and 20 cover a process of measuring pressure and would be classifiable in Class 73, Sub. 31 in Div. 36 as indicated by the above cited patent to Lehmann.

II. Claims 12 to 17, both inclusive, cover a process of determining the level of liquid in a well and would be classifiable in Class 177, Sub. 352 in Div. 42 as indicated by the above cited patent to Lehr et al.

III. Claims 21 to 25, both inclusive, cover a method of determining the potential production capacity of an oil well and would be classifiable in Class 166, Sub. 21 in Div. 38 as indicated by the above cited patent to Doherty.

IV. Claims 26 to 33, both inclusive, cover a method of determining density and would be classifiable in Class 265, Sub. 44 in Div. 36 as indicated by the above cited patent to Hay.

Division between these groups is required in accordance with Rule 42, Rules of Practice. Applicant must limit his claims to a single invention. The above cited patents show that the four devices have acquired independent status.

Claim 34 is rejected as failing to "particularly point out and distinctly claim" the invention as required by Section 4888, Revised Statutes.

After election, the statement of objects should be restricted to the subject matter of the invention, the claims to which Applicant elects to prosecute.

A. D. McFADYEN
Examiner.

Defendant's Exhibit Q—(Continued)

Application Div. Apr 25 '38 U. S. Patent Office.
U. S. Patent Office Apr 26 1938 Division 36

In the United States Patent Office
Division 36 — Room 7892

Cranford P. Walker,

Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells,

Filed October 26, 1937,
Serial No. 171,170.

Los Angeles, California,
April 18, 1938.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

In response to the Office action of February 5, 1938, please amend the above identified application as follows:

Page 2, Line 21, change "any" to read —may—.

Page 14, Line 12, pluralize the word "pressure".

Page 17, Line 24, change the comma to a semicolon.

Page 19, Line 8, before "the" insert —and—.

Claim 5, Line 3, change "pipe" to read —pump—.

Claim 10, Line 5, change "feed" to read —feet—.

Claims 18, 19 and 20, Line 3, change "to allow" to read —and building up the pressure of—.

Cancel Claim 34.

Defendant's Exhibit Q—(Continued)

REMARKS

With reference to the question raised by the Examiner in the second paragraph of the last Office action as to how the applicant knows that the lines connecting points D and E in Fig. 5 and the line connecting points G and H in Fig. 6 will be straight lines, it is a peculiar characteristic of most oil wells observed by the applicant that in plotting actual measurements of pounds per square inch against the production in barrels per day, as described in the specification of this application, the various points which are plotted are found to be substantially in a straight line so that projection of a straight line intersecting two or more of the points plotted, as indicated in Figs. 5 and 6, will permit the determination of the ratio in barrels per day against pressure at the pump for any other values of pump pressure. Careful plottings of these values over a considerable period of time show that any variation of the actual values from such straight line are so small as to be negligible.

The intersection of the line D and E with the zero pressure line represents a theoretical operation of a pump at such speeds and such stroke as to balance the pressure of the gas and of the oil within the well so that the pump is removing the oil from the well at the same rate at which the oil is flowing into the well from the sand. In other words, if a pump should be so operated as to remove the oil at exactly the same rate at which the oil flows into the well, a

Defendant's Exhibit Q—(Continued)

condition of zero pressure at the pump inlet would result. Many oil wells are now being operated at from only 5 to 15 pounds of casing pressure while in certain oil districts, such as Signal Hill in California, pumps are being operated with as much as 22 inches vacuum or a sub-zero pressure. With a casing pressure of 1 pound on a well 5000 feet deep and containing heavy gas, the pressure at the pump under such conditions would be only 3 pounds per square inch or less, that is, substantially zero pressure at the pump inlet.

The statements made in the specification relative to the points D-E and H-G lying in a straight line and that for other values of pump pressure the plotting of the barrels per day would lie along such straight line is not the mere propounding of a theory by the applicant but is the result of actual calculations based upon experiment, measurement and calculation. In answer to the Examiner's criticism of Fig. 3 of the drawing, the casing 1 is not sealed from the oil below the pump, there being represented diagrammatically in this drawing a screen liner at the bottom of the well into which the pump projects, the liner sealing with the casing, but the pump and its tubing extend down into the liner with considerable space between the exterior of the pump and the interior of the liner. This is common oil well pump practice and if there is any possibility of misunderstanding of the showing in the drawing, the applicant will be pleased to amplify the illustration as by breaking the liner and showing the same in

Defendant's Exhibit Q—(Continued)

section to illustrate the manner in which the pump and tubing are spaced from the liner. The Examiner's suggestion along this line will be appreciated.

Reconsideration of the requirement for division is respectfully requested. The applicant has disclosed in this application the method for making a series of calculations necessary and desirable for the most efficient production from oil wells and each of the claims is directed to a method for measuring and determining certain desired values necessary to be obtained and to be used for the efficient operation of wells.

While it is true that there are disclosed several uses for the information which is obtained, all of these uses are related to each other for producing desired oil well characteristic information.

One generic characteristic may be observed in all of the claims, namely, that the production of the information and the determination of all of the values depends upon observing the location of the level of the liquid surface in the well.

The claims which the Examiner has indicated should be grouped as Group I are all directed to the method of determining the pressure at any desired level in the column of liquid in the well; the method of determining the potential capacity of the well, claims to which the Examiner has grouped as Group III, depend upon first determining the pressure at any desired level in the liquid column, such determination being made by the method defined in the

Defendant's Exhibit Q—(Continued)

claims of Group I; the determination of the density of the liquid, claims to which the Examiner has grouped in Group IV, are likewise based upon first determining the liquid level in the well by the steps included in the determination of the pressure as defined in Group I.

As to Group II, it is believed that these claims are "sub-combination claims" under Group I rather than independent of Group I since each of these claims is addressed to a determination of the pressure of the liquid at a predetermined level in the well, namely, the inlet of the pump, and the method which is followed to obtain this information constitutes either (a) the observation of the fact that the liquid level is at the pump inlet, or (b) depressing the liquid level to the pump inlet and determining when the level has arrived at this point.

It will therefore be seen that all of the claims are addressed to such interrelated and interdependent subject matter that to require the applicant to divide this case into four parts as indicated by the Examiner, would not only work an entirely unnecessary hardship upon the applicant but would result in the separate classification of the different groups of claims in different classes when all of these claims should be classified in the same class.

The art which the Examiner has cited to indicate the probable classification of the several groups of claims does not show that these groups would be entirely classifiable as indicated by the Examiner.

Defendant's Exhibit Q—(Continued)

The patent to Lehmann is not directed to a method of determining liquid pressure in oil wells and to classify the claims of Group I (and II) in the same class with the Lehmann invention would be to place them in a field of search entirely foreign to the essence of the applicant's invention as expressed in these claims.

The patent to Doherty, cited to indicate proper classification of the claims of Group III, is not directed to a method for determining the production capacity of an oil well but instead is directed to a method of operating an oil field, there being no relation or similarity of any character between the subject matter of the Doherty patent and the subject matter of the claims of Group III.

The patent to Hay, cited to show classification of the claims of Group IV, discloses a piece of apparatus which may be used to measure the specific gravity of a small quantity of liquid placed in a container of predetermined size but does not show and has no relation to a method of determining the density of oil at a certain level within an oil well under the conditions existing in the well.

It is interesting to note that at this point there appears to be some doubt as to the proper classification of methods and apparatus for measuring liquid level, liquid pressure, density and production capacity in oil wells, the applicant having on file three applications directed to these problems, the generic feature of all of which is the determination of the liquid level and yet each of these three applications

Defendant's Exhibit Q—(Continued)

has been assigned to a different division and to a different class, namely, the present application No. 171,170 has been assigned to Division 36, application No. 162,699, filed September 7, 1937, has been assigned to Division 5, while application No. 164,534, filed September 18, 1937, has been assigned to Division 42.

The patent to Lehr, et al. which has been cited by the Examiner as indicative of proper classification of the claims of Group II, would appear to be representative of the proper classification for all of these applications and all of the claims in the present application since the claims of the Lehr, et al. patent more nearly represent the character and type of invention to which all of these applications are addressed.

It is believed that upon reconsideration of this requirement for division, it will be found that all the claims of this application are properly classifiable in a single class and are examinable in the same field of search.

In view of the fact that the first Office action in this case consisted solely of a requirement for division, it is believed that this application should be taken up for special action and that an early action upon the merits should be entered therein.

Respectfully submitted,

HAROLD W. MATTINGLY
Attorney for Applicant.

HWM:MM

Defendant's Exhibit Q—(Continued)

7892—#5

June 16, 1938

In re application of:
Cranford P. Walker
Ser. No. 171,170
Filed: Oct. 26, 1937

For: Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

Examiner, Division 36:

Division has been required among:

I. Claims 1-11, 18-20;
II. Claims 12-17;
III. Claims 21-25, and
IV. Claims 26-33.

Division is disapproved at present among groups I, III and IV since they are not distinct. There is considerable overlapping between the claims in these groups and they should be combined. The claims of group II are distinct from the remaining claims and the inventions covered thereby are not limited to use in the methods of the other claims. In re Ferenci, 1936 C. D. 373 and 445.

Division between:

I. Claims 1-11, [illegible]-33 and
II. Claims 12-17

is approved.

Respectfully,
B. E. LANHAM
Associate Examiner,
Classification Division.

BEL:AF

Defendant's Exhibit Q—(Continued)

#6

In the United States Patent Office

U. S. Patent Office Apr 28 1938 Division 36.

Application Div. Apr 28 '38 U. S. Patent Office.

In re Application of
Cranford P. Walker
Serial No. 171,170
Filed October 26, 1937

Method of Determining Fluid Density, Fluid Pressure and the Producing Capacity of Oil Wells

Los Angeles, Calif., April 19, 1938.

ASSOCIATE POWER OF ATTORNEY

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Please recognize Raymond Jones, of 1427 Eye Street, N. W., Washington, D. C., as associate in the above entitled application. Send all correspondence to attorney of record.

Respectfully,

HAROLD W. MATTINGLY
Attorney of Record.

HWM:WN

Defendant's Exhibit Q—(Continued)

260

Div. 36 Room 7892

Buchler/Bu

Department of Commerce

United States Patent Office

Washington

Address only

"The Commissioner of Patents,

Washington, D. C.,"

and not any official by name

Paper No. 7

All communications respecting this application should give the serial number, date of filing, and name of the applicant

Mailed Jun 20 1938

Please find below a communication from the EXAMINER in charge of this application.

CONWAY P. COE

Commissioner of Patents,

Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope St.,
Los Angeles, Calif.

Applicant: Cranford P. Walker
Ser. No. 171170
Filed Oct. 26, 1937
For Method of Determining Fluid Density, etc.

In response to amendment filed April 25, 1938.

With regard to Fig. 3, there is apparently shown

Defendant's Exhibit Q—(Continued)

a collar surrounding tubing string 5, which collar is about two inches above the bottom end of the screen in Fig. 3. This collar, as shown in Fig. 3, appears to prevent communication between the space in the casing 1 above and below the collar. If this collar is merely a spider, it would apparently be sufficient merely to state this fact.

Claims 1 to 33, inclusive, are in the case.

The requirement for division has been submitted to the Examiner of Classification who states:

"Division has been required among:

I. Claims 1-11, 18-20;
II. Claims 12-17;
III. Claims 21-25, and
IV. Claims 26-33.

Division is disapproved at present among groups I, III and IV since they are not distinct. There is considerable overlapping between the claims in these groups and they should be combined. The claims of group II are distinct from the remaining claims and the inventions covered thereby are not limited to use in the methods of the other claims. In re Ferenci, 1936 C. D. 373 and 445.

Division between:

I. Claims 1-11, 18-33 and
II. Claims 12-17

is approved."

Therefore with the approval of the Examiner of Classification, the requirement for division between

(I) Claims 1 to 11, inclusive, and 18 to 33, inclusive, and

Defendant's Exhibit Q—(Continued)

(II) Claims 12 to 17, inclusive is now MADE FINAL.

A. D. McFADYEN
Examiner

#8

U. S. Patent Office Jul 11 1938 Division 36.
Mail Division Jul 9,1938 U. S. Patent Office.

In the United States Patent Office
Division 36
Room 7892

Cranford P. Walker

Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells

Filed: October 26, 1937
Serial No. 171,170

Los Angeles, California
July 5, 1938

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In response to the Office action of June 20, 1938, the applicant herein elects to prosecute claims 1 through 11 and 18 through 33 in the present application and under the provisions of Rule 42, it is requested that claims 12 through 17, not elected, be retained in this case for the purposes of appeal.

The Examiner's criticism of Fig. 3 of the drawings is believed to be due to a misunderstanding of

Defendant's Exhibit Q—(Continued)

the parts illustrated therein. The lower end of the casing 1 is illustrated as having attached thereto a "perforated liner" which is secured to the casing as by means of the collar referred to by the Examiner. It will be appreciated that this collar has an internal diameter in excess of the external diameter of the tubing 5 or the pump 4 so that the tubing and pump may extend through the collar and into the liner and yet provide an annular space therebetween completely surrounding the pump and tubing. This space will readily permit the pressure impulses to pass down between the pump tubing and the liner, although a distinct echo will be produced by the top or collar of the lining as indicated in the graphs of the measurements made by the applicant's instrument as disclosed in his co-pending application, Serial No. 162,699, referred to in the body of this specification (now being examined in Division 5).

If, in view of the foregoing explanation, the Examiner feels that this collar and its arrangement should be more amply described in the specification, the applicant will be pleased to do so, but since this forms no part of the present invention and is merely a diagrammatic illustration of a well known and common practice in the industry, it is not believed such detailed description is necessary.

In view of the foregoing election, which has been made promptly in response to the Office action, and in view of the fact that no action on the merits of

Defendant's Exhibit Q—(Continued)

this application has been made up to the present time, it is believed that this application should be made special for the next Office action, under Commissioner's Order 2670, and an early, favorable action on the merits is requested.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant

HWM mm

#9—B

Application Div. Oct 15 '38 U. S. Patent Office.
U. S. Patent Office Oct 17 1938 Division 36.

In the United States Patent Office
Division 36 — Room 7892

Cranford P Walker
Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells,

Filed October 26, 1937
Serial No. 171,170

Los Angeles, California
October 4, 1938

Hon. Commissioner of Patents
Washnigton, D. C.

Sir:

Supplementing the amendment of July 5, 1938, please amend the above identified application as follows:

Defendant's Exhibit Q—(Continued)

Page 3, Line 26, change "taking" to read —making—.

Please add the following claims:

~~35. The method of determining the potential~~ production capacity of an oil well having a mechanical pump therein and without requiring removal of the pump parts, which consists in determining the location of the liquid level under one stable rate of production by said pump, computing the effect in pressure of the height of the liquid column between said level and some known location below the liquid surface; changing the rate of production by said pump by altering the speed or length of stroke of said pump; determining the level of the liquid under the new rate of production when stabilized, computing the pressure effect of the height of the liquid column between its new level and said known location; comparing the change in liquid pressure at said known location and using the ratio thus found to determine the rate of production for any other pressure at said known location.

—36. The method of determining the potential production capacity of an oil well having a mechanical pump therein and without requiring removal of the pump parts, which consists in locating the liquid level under one condition of production by said pump; altering the production rate of said pump and locating the liquid level under said new rate of production of said pump, comparing the two fluid levels so determined and using the ratio thus found ~~to calculate the rate of production when the fluid~~

Defendant's Exhibit Q—(Continued)

level is at the inlet of the pump or at any other location below said test levels.

—37. The method of determining the potential production capacity of an oil well having a mechanical pump therein and without requiring removal of the pump parts, which consists in locating the level of the liquid surface when the pump is idle, operating the pump at some actual producing rate, locating the level of the liquid surface under said actual producing rate of production of said pump, comparing the two fluid levels so determined and using the ratio thus found to calculate the fluid rate when the fluid level is at the inlet end of the pump or at any other locations below said test levels.

—38. The method of determining the potential capacity of an oil well having a mechanical pump therein and without requiring removal of the pump parts, which consists in determining the static pressure at the pump or other known location below the surface of the fluid by locating the level of the liquid surface when the pump is idle, computing the effect in pressure of the height of the column of liquid between said level so located and the inlet of the pump or other known location; operating the pump at one rate of production thereof and locating the stable liquid level under that rate of production, computing the effect in pressure of the height of the column of liquid between the new level so located and the inlet of the pump or other known location, comparing the difference between said pressures with the difference in the two fluid levels and using

Defendant's Exhibit Q—(Continued)

~~the ratio so found to calculate the rate of produc~~ tion for zero or ~~any other~~ pressure at the pump ~~inlet or said other known location.~~

REMARKS

The new claims submitted herewith have been drawn upon a review of this application to cover certain features of the applicant's invention peculiarly adapted for certain wells.

As was explained in the specification, the determination of the maximum production capacity of an oil well has been discovered by the applicant to be in substantially direct proportion to changes in the location of the fluid level or to changes in the operating pressure at the pump or some other location below the normal liquid level in the well. Where the well is making a considerable quantity of gas and the effect of this gas is to produce a pressure upon the liquid surface, the effect in pressure of this gas must be taken into consideration in order that the calculations produce an accurate result. Also under such conditions of wells making large quantities of gas, the density of the liquid (which varies with the amount of gas made by the well and with the level at which the calculations are to be computed) must also be taken into consideration. However, many wells make little or no gas so that the effect of gas pressure may be disregarded and likewise the density of the liquid may be assumed to be the gravity of the liquid as measured at the ground surface.

Defendant's Exhibit Q—(Continued)

It has been the applicant's discovery that there is a direct ratio between the location of the liquid level under two different rates of production from the pump, whether zero production from the pump (static conditions) and some other producing rate from the pump or between two different producing rates of the pump, and that this ratio is constant for other rates of production and the corresponding stable levels of the liquid. This may be stated and employed in calculations either in terms of ratio of liquid level or in terms of pressure beneath the surface of the liquid. It is therefore believed that the applicant is entitled to claims of the character now inserted.

Claim 35 defines this subject matter as including the steps of locating the liquid level at different rates of production of the pump and computing the effect in pressure of the liquid column above either the pump inlet or other known location below the liquid surface to determine the pressures at the known location or pump inlet under the two operating conditions and employing the ratio of such pressures as illustrated particularly in Figs. 5 and 6.

Claim 36 defines this subject matter in terms of liquid level wherein the density of the liquid, being known, and the effect in gas pressure being so nearly zero as to be negligible, the calculation of the maximum production capacity may be made merely by using the ratio of the two liquid levels at different rates of production, which may be either zero and another rate or two rates above zero.

Defendant's Exhibit Q—(Continued)

Claim 37 defines the same subject matter as Claim 37, but is specific to the utilizing as one of the "production rates", the zero production rate or static condition in the well.

Claim 38 defines the same subject matter as Claim 35, but, like Claim 37, is specific to utilizing as one of the production rates the zero production rate or static condition of pressure in the well.

It is respectfully requested that these claims are clearly allowable and an early favorable action upon all of the claims in this application is respectfully requested.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant.

HWM:MM

Defendant's Exhibit Q—(Continued)

Div. 36 Room 7892

260

Buchler:mwc

Paper No. 10

Mailed Nov 1-1938.

Department of Commerce
United States Patent Office
Washington
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name
All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE,
Commissioner of Patents.

Harold W. Mattingly,
924 Pacific Finance Bldg.,
631 S. Hope St.,
Los Angeles, California.

Applicant: Cranford P. Walker
Ser. No. 171170
Filed Oct. 26, 1937

For Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells

Defendant's Exhibit Q—(Continued)

Responsive to amendment filed October 5, 1938.

Additional references cited and relied upon for rejection:

An article entitled "Bottom-hole Pressures in Oil Wells" by C. V. Millikan and Carroll V. Sidwell on pages 194 to 206, inclusive, of the 1931 volume of the Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, Petroleum Division, published by the Institute, 29 West 39th St., New York, N. Y., (Copy in Library of Congress, Washington, D. C. Call number TN 860 A4);

An article entitled "Density of Oil-gas Columns from Well Data" by W. V. Vietti, on pages 215 to 220 of the 1931 volume of the Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, Petroleum Division, published by the Institute, 29 West 39th St., New York, N. Y. (Copy in Library of Congress, Washington, D. C. Call No. TN 860 A4);

An article entitled "Subsurface Pressures in Oil Wells and Their Field of Application" by D. G. Hawthorn on pages 148 to 169 of the 1933 volume 103 of Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, Petroleum Division, published by the Institute, 29 West 39th St., New York, N. Y. (Copy in Li-

Defendant's Exhibit Q—(Continued)

brary of Congress, Washington, D. C., Call No. TN 860 A4);

An article entitled "Determination and Application of Depth Pressures in the Yates Field" by Dale Nix on pages 353 to 366 of the 1932 volume of Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, Petroleum Division, published by the Institute, 29 West 39th St., New York, N. Y. (Copy in Library of Congress, Washington, D. C.);

An article entitled "Measurements of Original Pressure, Temperature and Gas-Oil Ratio in Oil Sands" by K. C. Sclater and B. R. Stephenson of Ponca City, Oklahoma, said article being found on pages 119 to 136 of Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, 1928, 1929, Petroleum Division, Published by the Institute, supra, 29 West 39th St., New York, N. Y. (Copy in Library of Congress, Washington, D. C.);

Staneliffe,	1,457,406,	June 5, 1923,	(265-44);
Field,	1,519,609,	Dec. 16, 1924,	(");

Additional references cited for Applicant's information:

Rockliff,	503,330,	Aug. 15, 1893,	(73-31-5uxr);
Dexter,	1,100,867,	June 23, 1914,	(73-31-6 xr);
Rathbone,	1,406,682,	Feb. 14, 1922,	(73-51 Oil Well);
Doherty,	1,899,497,	Feb. 28, 1933,	(73-31-6 uxr);

Defendant's Exhibit Q—(Continued)

Subkow,	1,907,608,	May 9, 1933,	(73-31-5 xr);
Foran et al,	2,082,329,	June 1, 1937,	(73-51 Oil Well);
Collins,	1,822,203,	Sept. 8, 1931,	(73-31-5 uxr);
Dunn et al,	1,946,575,	Feb. 13, 1934,	(166-1 uxr);
Wolf,	2,115,379,	Apr. 26, 1938,	(73-151 xr);
Marx,	1,955,855,	Apr. 24, 1934,	(166-1 uxr);

An article entitled "Reservoir Pressure in the Hobbs Field, New Mexico" by R. S. Christie on pages 342 to 352 of the 1932 volume of Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, Petroleum Division, published by the Institute, 29 West 39th St., New York, N. Y. (Copy in Library of Congress, Washington, D. C.);

An article entitled "Increasing Ultimate Recovery of Oil" by S. F. Shaw on pages 178 to 188 of the 1931 Volume of Transactions of American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, Petroleum Division. Published by the Institute, 29 West 39th St., New York, N. Y. (Copy in Library of Congress, Washington, D.C.);

The drawing should show a pressure gage connected to the casing head.

Claims 1 to 33 and 35 to 38 are in the case.

Since claims 12 to 17, inclusive, cover an invention not elected, these claims are not examined in this action. Claims 12 to 17 should be disposed of before the time of allowance.

Defendant's Exhibit Q—(Continued)

Claims 1 to 10, inclusive, 19 and 20 are rejected as covering the obvious steps of determining the pressure at the liquid surface in a well.

Claims 1 to 5, inclusive are further rejected as fully met by the above cited article from the 1928-1929 volume of Transactions of the American Institute of Mining and Metallurgical Engineers, particularly pages 124 and 135. The matter at the top of page 124 and at the bottom of page 135 teach the method claimed.

In line 6 of claim 2, "located" should be locate.

Claim 3 is rejected as indefinite since it is not apparent what column is meant by "column of fluid" of the last step.

Claim 3 is further rejected as indefinite. If the gas pressure upon the liquid surface is noted, as stated in the third step, why is it necessary to compute such pressure, as stated in the fourth step?

Claim 8 is further rejected as incomplete because line 11 fails to state that the pressure is measured at the casing head.

Claims 1 to 10, inclusive, 19, and 20 are further rejected as failing to define inventions which fall within one of the statutory classes of invention named in Section 4886, Revised Statutes. Claims 1 to 5, 7, 8, 10, 19 and 20 merely cover computing methods. Claims 6 and 9 merely cover a method of making a drawing.

Claim 18 is rejected as unpatentable over Lehr et al, of record. Anyone has a right to use the device of Lehr et al to measure any liquid level in a

Defendant's Exhibit Q—(Continued)

well. Therefore, it would not be invention to use the device of Lehr et al to determine the stable liquid level in a well.

Unless Applicant can point out a basis in the description for the step in lines 12 to 16 of claim 21, the description should be amended to provide a more definite basis for claim 21.

Claim 22 is rejected as incomplete because the last step of comparing the pressures is insufficient to determine the potential production capacity.

Claim 22 is further rejected as incomplete because the last step fails to state that the zero pressure is at the pump inlet.

Claims 23 and 24 are rejected as broader than the invention because each states that the pressures may be measured "at any other location near the bottom of the well".

Claims 26 to 33, inclusive, are rejected as covering the obvious way of measuring density.

Claims 26 to 33, inclusive, are further rejected as failing to define inventions which fall within one of the statutory classes of invention named in Section 4886, Revised Statutes. These claims merely state a method of computation.

Claims 26 to 33, inclusive, are further rejected as unpatentable over Hay, of record, or Stancliffe, supra, or Efeld, supra. Each of these patents teach that the density of a liquid may be determined by measuring the pressures at two spaced locations in the liquid. In view of such teachings, it would not

Defendant's Exhibit Q—(Continued)

be invention to determine the density of the oil in a well by dividing the difference in pressures at two locations by the distance between such locations.

Unless Applicant can point out where the description states that the pump is operated during the determination of density, the description should be amended to provide a more definite basis for claim 29.

Claim 33 is rejected as incomplete because lines 8 and 9 fail to state that the difference in pressure is utilized.

Claims 35 and 38 are rejected as involving new matter because the original description failed to state capacity of a well could be determined merely from the pressures due to liquid columns.

Claims 35 and 38 are further rejected as involving new matter because the original specification failed to state that "the rate of production for any other pressure" could be determined merely from the ratio of two pressures.

Claims 36 and 37 are rejected as involving new matter because the original specification failed to disclose that the potential production capacity of a well could be determined by merely comparing two fluid levels.

Claims 35, 36, 37 and 38 are further rejected as failing to define inventions which fall within one of the statutory classes of invention named in Section 4886, Revised Statutes. These claims merely state steps of computing.

Claims 36 and 37 are further rejected as unpat-

Defendant's Exhibit Q—(Continued)

entable over Lehr et al, of record. It would not be invention to use the device of Lehr et al to determine the liquid levels in a well under two rates of production for the purpose of determining potential capacity.

Claim 38 is further rejected as involving new matter because the original specification failed to state that the potential capacity of the well could be determined from pressures at "other known location below the surface of the fluid".

Claim 38 is further rejected as indefinite. Why is the static pressure at the pump determined, as stated in the first step, when this static pressure is not used to compute the potential capacity?

Claims 21 and 25 are rejected and claims 22, 23 and 24 are further rejected as failing to define inventions which fall within one of the statutory classes of invention named in Section 4886, Revised Statutes. These claims merely state steps of computing and are therefore not within one of the statutory classes of invention entitled to patent protection.

Claim 21 is further rejected as incomplete because line 16 fails to state that the pressure is at the casing head.

Claim 22 is further rejected as incomplete since sufficient steps are not included for determining the pressures. Merely measuring the casing head pressure and the liquid level is not sufficient to determine the pressures.

Defendant's Exhibit Q—(Continued)

Claims 21, 23, 24 and 25 are further rejected as misleading and broader than the invention because each states, in the last three or four lines, that the rate of production is determined "at other locations . . .".

Unless Applicant can point out where the description provides a basis for the second step of claim 25, the description should be amended to provide such basis.

Claims 26 and 27 are further rejected as incomplete since each fails to state that the pressures are measured at the liquid surfaces.

Claims 36 and 37 are further rejected as involving new matter since the original specification failed to state how the rate of production "at any other location . . ." could be determined by comparison of two fluid levels.

Claims 1 to 5, inclusive, 10, 19 and 20 are further rejected as fully met by page 194 of the 1931 volume of Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Division, supra.

Claims 7 and 8 are further rejected as unpatentable over pages 194 and 216 of the 1931 volume and page 150 of the 1933 volume of Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Division, supra. It would not be invention to obtain the density of the liquid in an oil well by the method described on page 216 of the 1931 volume or page 150 of the 1933 volume

Defendant's Exhibit Q—(Continued)

and to use the density in performing the computations states on page 194 of the 1931 volume.

Claims 21 to 25, inclusive, and 35 to 38, inclusive, are further rejected as unpatentable over pages 194 and 216 of the 1931 volume and pages 152, 153 of the 1933 volume of Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Division, supra. It would not be invention to determine pressures in a well by finding the density of the liquid by the method stated on page 216 of the 1931 volume and thereafter computing the pressures by the method stated on page 194 of the 1931 volume and thereafter plotting the pressures and productions as illustrated on page 216 of the 1931 volume and pages 152, 153 of the 1933 volume to determine the maximum potential capacity.

Claims 26 to 33, inclusive, are further rejected as unpatentable over page 150 of the 1933 volume or page 216 of the 1931 volume of the Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Division, supra. These pages teach how density may be measured by comparing height of a column of oil and the pressures. It would not be invention to determine the pressures and height of the column by depressing the liquid level in the well.

Claims 6, 9 and 18 are further rejected and claim 11, is rejected as unpatentable over pages 353 and 354 of the 1932 volume of Transactions of the American Institute of Mining and Metallurgical Engi-

Defendant's Exhibit Q—(Continued)

neers, Petroleum Division, supra. These pages disclose the measurement of pressure and liquid level. It would not be invention to make a graph using such measurements. It is noted that claim 11 states that the arrival of the liquid surface at the pump is determined by detecting waves produced by the pump. Since it is well known that a liquid pump will create a pressure wave when a portion of gas gets into the pump, it would not be invention to determine the arrival of the liquid level at the pump inlet by detecting pressure waves.

Claims 21 and 24 are specific to the method graphically illustrated in Fig. 6 because each includes the steps of "determining the pressure . . . while the pump is operating at one rate . . ." and "changing the rate . . .". Claims 22 and 23 are specific to the method graphically illustrated in Fig. 5 because each includes the steps of "determining the . . . non-producing pressure . . ." and "determining the pressure . . . when the pump is operating . . .". Claim 25 is specific to the method illustrated in Fig. 6 because it includes the steps of "determining the . . . pressure . . . when the pump is operating at its normal . . . rate . . ." and "reducing the producing rate. . .".

Claim 35 is specific to the method illustrated in Fig. 6 because it includes the steps of "determining the location of the liquid level under one . . . rate of production by said pump . . ." and "changing the rate of production . . .". Claim 36 in specific to the method illustrated in Fig. 6 because it in-

Defendant's Exhibit Q—(Continued)

cludes the steps of "locating the . . . level under one . . . production . . ." and "altering the production rate . . .". Claims 37 and 38 are specific to the method illustrated in Fig. 5 because each includes the step of "locating the level . . . when the pump is idle".

The claims include claims specific to each of more than one species of invention as follows:

I. Claims 21, 24, 25, 35 and 36 are specific to the method illustrated in Fig. 6.

II. Claims 22, 23, 37 and 38 are specific to the method illustrated in Fig. 5.

There being no generic claim, Applicant must restrict his specific claims to one species before further action on the merits will be given. Sub-combination claims 1 to 20 and 26 to 33 may go with either group.

All of the claims, except claims 12 to 17, have been examined in order to expedite the prosecution.

A distinct line of division should be maintained between this application and all copending applications of the same inventor.

A D. McFADYEN,
Examiner.

Defendant's Exhibit Q—(Continued)

Mail Division Jan 3 1939. U. S. Patent Office.
U. S. Patent Office, Jan 4 1939. Division 36.

In the United States Patent Office
Division 36—Room 7892

Cranford P. Walker
Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

Filed October 26, 1937
Serial No. 171,170

Los Angeles, California
December 29, 1938

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In response to the Office action of November 1, 1938, please amend the above identified application as follows:

Page 23, line 23, before the period, insert

(C1)

—(the liquid surface being at the pump inlet, its density may be disregarded in the calculations for production capacity).

Page 25, Line 2, after the period, insert

(C2)

It should also be noted that all of the measurements necessary to provide for the computations and calculations explained herein may be accomplished without interrupting the operation of the

Defendant's Exhibit Q—(Continued)

pump except for the measurement of the static pressure as described herein.

Cancel Claims 1 through 11 and substitute the following:

(C3)

~~39. The method of determining the liquid pressure~~ at any desired level below the surface of the liquid in an oil well having a casing and a mechanical pump suspended therein on tubing and without requiring removal of the pump parts, which consists in the steps of altering the pressure of the gas within the casing to move the liquid surface to the desired level, determining when the liquid surface has reached the desired level, noting the distance between the new level of the liquid surface and the casing head, and noting the casing head pressure of the gas required to so move the liquid surface to the new level whereby the liquid pressure at the desired level is represented by the sum of the noted casing head pressure and the effect in pressure of the column of gas between the liquid surface and the casing head.

—40. The method of determining the liquid pressure at any desired level below the surface of the liquid in an oil well having a casing and a mechanical pump suspended therein on pump tubing and without requiring removal of pump parts, which consists in the steps of maintaining a stable condition of gas pressure in the casing, operating the pump until the liquid level becomes stable, measuring the distance between the casing head and the

Defendant's Exhibit Q—(Continued)

~~surface of the liquid under said stable conditions~~ and while the pump is operating, noting the distance between the surface of the liquid and the desired level, and noting the casing head pressure under said stable condition whereby the pressure at the desired level is represented by the sum of the casing head pressure, the effect in pressure of the column of gas between the liquid surface and the casing head, and the effect in pressure of the weight of the liquid column between the liquid surface and ~~the desired level.~~

1—~~41~~. The method of determining the ~~liquid~~ ~~pres~~ density of the standing column of liquid ∧ ~~sure at any desired level below the surface of the liquid~~ in an oil well having a casing and a mechanical pump suspended therein upon pump tubing and parts without requiring the removal of ~~the~~ pump ∧, which consists in the steps of operating the pump under one stable condition of gas pressure in the casing until the liquid level becomes stable, measuring the distance between the casing head and the surface of the liquid under this stable condition, altering the casing pressure to a new condition, operating the pump at the same rate of production under the new condition of gas pressure to again stabilize the liquid level, measuring the distince between the casing head and the new level of the liquid surface under said new stable condition, and ∧ measuring ~~noting~~ the casing head pressures under the two stable conditions,

Defendant's Exhibit Q—(Continued)

whereby the pressure exerted by the liquid per unit of height of the liquid is represented by comparing the difference in height of the liquid surface levels and the difference between the gas pressures on the liquid surface required to maintain the liquid surface at the two levels.

~~—42. The method of determining the pressure~~ of liquid at the inlet of a mechanical pump suspended in an oil well upon pump tubing and without requiring removal of pump parts, which consists in measuring the distance between the casing head of the well and the pump inlet, building up within the casing a gas pressure sufficient to maintain the liquid surface at or approximately at the level of the pump inlet, determining when the liquid surface is at the pump inlet, and noting the casing head pressure of gas required to maintain the liquid surface at such location, whereby the pressure of the liquid at the pump inlet is represented by the sum of the noted casing head pressure and the effect in pressure of the gas column between the pump inlet and the casing head.—

Cancel Claims 18, 19 and 20 and substitute the following:

C4

—43. The method of determining the static pressure at any point below the liquid surface of a well having a casing and a mechanical pump suspended therein on pump tubing and without requiring the removal of pump parts, which consists ~~in the steps of measuring the distance between the~~

Defendant's Exhibit Q—(Continued)

~~normal liquid level when gas is flowing from the~~ casing head and the pump is not operating, noting the casing head pressure under these conditions, closing the casing and allowing the gas within the well to depress the surface of the liquid to a new stable level, measuring the distance between the new liquid level and the casing head, and noting the casing head pressure required to hold the liquid at the new level, whereby pressure exerted by the liquid per unit of height is represented by comparison of the difference in height of the two liquid levels with the difference in gas pressure exerted upon the liquid surface at the two levels.—

Cancel Claim 21 and substitute the following:

C5

—44. The method of determining the maximum potential capacity of an oil well having a casing and a mechanical pump suspended therein upon tubing and without requiring the removal of pump parts, which consists in the steps of maintaining one condition of gas pressure at the casing head while the pump is operating at one rate of production, measuring the distance between the liquid surface and the casing head under these conditions, changing the rate of production of the pump and while the pump is operating building up the gas pressure at the casing head to depress the liquid surface to a point approximately level with the pump inlet, measuring the distance between the new liquid surface level and the casing head, comparing

Defendant's Exhibit Q—(Continued)

the difference in height of the liquid surface under the two conditions with the difference in gas pressure on the liquid surface required to change the height of the liquid, and then comparing the amount of change in the production rate under the two conditions with the corresponding change in liquid pressures at the pump inlet under the two conditions, whereby the ratio thus found may be used to extrapolate the rate of production for zero or any other pressure at the pump or at other locations below the normal producing level of the liquid in the well:—

Cancel Claim 22 and insert the following:

C6

—45. The method of determining the potential production capacity of an oil well having a casing and a mechanical pump suspended therein on tubing and without requiring the removal of pump parts, which consists in determining the static or non-producing pressure of the liquid at the pump inlet by closing the casing head, allowable the pressure of gas escaping from the fluid to depress the level of the liquid to a stable condition while the pump is idle, measuring the distance between the surface of the liquid and the casing head under this condition, whereby the pressure at the pump inlet is represented by the sum of the casing head pressure, the effect in pressure of the gas column and the effect in pressure of the liquid column between the surface and the pump inlet; then deter-

Defendant's Exhibit Q—(Continued)

mining the pressure at the pump inlet when the pump is operated at a predetermined production rate by allowing the pump to operate at said production rate, measuring the distance between the casing head and the liquid surface when the pump is so operating, whereby the pressure at the pump inlet under this production rate is represented by the sum of the casing head pressure, the effect in pressure of the gas column and the effect in pressure of the column of liquid above the pump inlet, and comparing the difference in the two pressures of the liquid at the pump inlet with the difference between the static and operating production rates to determine the production capacity of the well at zero pressure of liquid at the pump inlet.—

Claims 23 and 24, Line 2, after "well" insert.

C7

—having a casing and a pump suspended therein and on tubing and without requiring removal of pump parts—.

Claim 25, Line 2, after "well" insert

C8

—having a casing and a pump suspended therein and on tubing and without requiring removal of pump parts,—.

Claims 26 and 27, Line 2, after "well" insert

C9

—having a casing and a pump suspended therein and on tubing and without requiring removal of pump parts,—; Line 3, change "well" to read —annular space between the pump tubing and the cas-

Defendant's Exhibit Q—(Continued)

~~ing—; Line 6, after "pressure" insert —on the~~ liquid surface—.

Claims 28, 29 and 30, Line 2, after "well" insert

C10

—having a casing and a pump suspended therein and on tubing and without requiring removal of pump parts,—; Line 3, change "well" to read —annular space between the pump tubing and the casing—.

Claims 31, and 32, Line 2, after "well" insert

C11

—having a casing and a pump suspended therein and on tubing and without requiring removal of pump parts,—.

Claim 33, Line 2, after "well" insert

C12

having a casing and a pump suspended therein and on tubing and without requiring removal of pump ~~parts,—~~; Line 3, change "well" to read —annular space between the pump tubing and the casing—; Line 9, change "pressure" to —difference between the pressures—.

Claims 35, 36 and 37, Line 2, before "pump" insert —mechanical—; same line, after "therein" insert —and without requiring removal of the pump parts—.

Claim 38, Line 2, before "pump" insert —mechanical—; same line, after "therein" insert —and without requiring removal of the pump parts—; Line 13, after "comparing" insert —the difference between—; Line 14, after "pressures" insert —with the difference in the two fluid levels—.

Defendant's Exhibit Q—(Continued)

REMARKS

In view of the last Office action, this application has been carefully reviewed.

The "Examiner's statement that the pressure gage at the casing head should be shown is noted. However, it is requested that this correction to the drawing be held in abeyance until the allowance of claims in this application.

The Examiner's rejection of the claims in this application on the ground that they do not fall within the statutory classes of invention but merely define methods of computing is believed to be incorrect since the applicant is not attempting to claim the mathematics nor the mathematical computation of the various results but he is claiming those physical steps which are required to obtain the factors necessary to make the calculations.

However, Claims 1 through 11 have been cancelled and new Claims 39 through 42 are presented herewith, each of these claims being drawn to the methods specified which includes the series of physical steps necessary to obtain the factors and then in a "whereby" clause the usefulness or the result which can be obtained by using these factors in computations is stated. It is believed that this form of claim avoids the Examiner's criticism in that the computations stated in the "whereby" clause do not constitute a claiming of the computations as steps in the method but are merely illustrative of

Defendant's Exhibit Q—(Continued)

the manner in which the factors obtained by the physical steps can be successfully utilized to achieve the result sought.

In the same manner Claims 18, 19, 20, 21 and 22 have been cancelled and new Claims 43, 44 and 45 substituted, drawn along the same lines as Claims 39 through 42.

However, the remaining claims in this application have been left in their original form except to make such amendments as inserting features inadvertently left out of these claims on their original draft. Each of these claims does not depend for its patentability upon the computations nor upon the precise mathematics involved but sets forth the physical steps which are required to be performed in order to obtain the information constituting the result of the employment of the applicant's method.

Before discussing the merits of the individual claims in this application, it is believed advisable to call the Examiner's attention to the fact that the applicant herein has presented certain methods of determining pressure of the liquid at any point below the surface thereof, of determining the density of the liquid in a well, and of determining the maximum production capacity of a well, all of which methods relate to and may be applied to wells containing mechanical pumps suspended upon pump tubing as distinguished from "flowing" wells. At the outset the Examiner must keep in mind that the conditions existing in "flowing" wells, that is, wells

Defendant's Exhibit Q—(Continued)

in which the liquid is forced to the ground surface by natural pressures in the formation and in the ground, are entirely different from those encountered in wells which are being mechanically pumped. For example, the pressure at one point below the liquid surface in a "flowing" well varies as the depth of such point below the liquid surface. Again the density of the liquid at any point in a "flowing" well varies as the depth of such point below the liquid surface.

A further condition which must be kept in mind is that in "flowing" wells the flow tubing is free of obstruction so that pressure bombs, pressure recorders and other instruments may be readily inserted into the well and lowered to the liquid surface. In wells which are being mechanically pumped it is impossible to lower any such instruments through the pump tubing without first removing the pump and it is impossible to place any such instruments down through the annular space between the pump tubing and the casing due to the fact that the tubing "corkscrews" down through the casing, leaving no unobstructed channel through which such instruments may pass.

Keeping in mind these facts, it will be apparent that the applicant has attacked an entirely new problem when he provides means and methods for determining the three factors, pressure, density and capacity, in a well being mechanically pumped and that he has provided such means and method as will

Defendant's Exhibit Q—(Continued)

permit determination of these factors without requiring the removal of any of the pump parts and with a minimum of time and effort required.

With regard to the claims directed to the meth- of determining the pressure (original Claims 1 through 11), Claims 1 through 11 have been rewritten as Claims 39 through 42, in which it is definitely stated that the method applies to wells in which mechanical pumps are employed for pumping the well and then follows the steps of the method of determining the pressure at any point below the liquid surface which in Claim 39 includes (a) the step of changing the pressure in the casing to move the level of the liquid to the desired level; (b) determining when the liquid surface has arrived at this level; (c) measuring the casing head pressure required to so locate the liquid level and adding to this pressure the effect of the weight of the gas column. This claim defines the method which has heretofore been uncontemplated and including two new steps, that of depressing the liquid from its normal level to the level at which the measurement is to be made and then determining when the liquid has arrived at this level.

At this point it should be noted that the applicant is not claiming that he has invented merely the step of adding the effect of the weight of the gas column to the casing head pressure since that is merely ordinary physics. The applicant is claiming the manner in which the casing head pressure can be related

Defendant's Exhibit Q—(Continued)

to the pressure of the liquid at any point below the normal liquid level.

The Examiner has referred to the following publications:

(1) Pages 124 and 135 of the 1928-1929 volume of Transactions of the American Institute of Mining and Metallurgical Engineers; and (2) Page 194 of the 1931 volume of the said institute. Both of these publications relate to and apply to only "flowing" wells. The first of these publications requires the lowering of a pressure responsive diaphragm into the well so that a direct reading of the pressure existing at the point at which the diaphragm is located may be made. This is not the method described by the applicant in Claim 39. The only contribution made by this article is the statement on Page 135 to the effect that the pressure for the diaphragm read at the casing head must be corrected for the weight of the gas column between the diaphragm and the casing head. This is not a disclosure of the applicant's method of measuring the pressure but in effect merely states that some pressure is exerted by the weight of the gas column. The applicant, on the other hand, does not lower a pressure responsive diaphragm but instead he merely reads casing head pressure (that is, the pressure in the entire casing as read on a gage merely coupled with the casing head) and he compensates for the gas column by first finding out where the liquid surface is and then calculating the effect in pressure

Defendant's Exhibit Q—(Continued)

of the column of gas between that location and the casing head.

The second of the publications on Page 194 merely states that the pressure at the bottom of the flow tubing may be calculated by adding to the casing head pressure the effect due to the weight of the gas column. This presupposes that the liquid surface is at the bottom of the flow tubing but, if it is not, gas may be introduced in the annular space about the flow tubing to insure that it is free of liquid. This article does not disclose how the pressure at any point below the liquid surface may be measured but merely discloses how liquid can be forced down to the level of the bottom of the flow tubing. As a matter of fact, unless the liquid is at the bottom of the flow tubing in a "flowing" well, any calculation of pressure as disclosed in this article would be entirely erroneous.

New Claim 40 is directed to the determination of the liquid pressure at any level below the surface including the steps of, first, operating the pump until the liquid level becomes stable, second, determining the location of the level under these conditions, third, adding to the casing head pressure the weight of the column of gas determined by measurement of the liquid level, and then adding the effect in pressure of the weight of the liquid column between the known surface of the liquid and the level or point at which the pressure calculation is desired.

Defendant's Exhibit Q—(Continued)

This claim defines steps not contemplated in any of the articles, particularly the step of determining where the liquid surface lies, to find the extent of the gas column and to permit determination as to how far below this surface the desired point lies at which the pressure measurement is to be made. None of the references contemplate any such steps and are totally lacking in any teaching which would result in this information.

Claim 41 introduces the still further steps of changing the gas pressure from one pressure to another to change the level of the liquid and to use the information as to the two liquid levels and the pressure required to create such change in the level as the means for determining the pressure at the desired point below the liquid surface. A most careful reading of both of the publications cited against this claim, as well as the remaining publications cited by the Examiner, fails to disclose any such steps other than merely that in order to obtain the pressure existing on the surface of the liquid it is necessary to add the weight of the gas column provided the length of such gas column is known but which none of the authors supply means or method for determining.

New Claim 42 introduces the additional step that the pump must operate at the same production rate under the new condition of gas pressure which is a still further condition not contemplated by any of the references.

Defendant's Exhibit Q—(Continued)

New Claim 43 defines the method by which the pressure at the inlet of a mechanical pump may be determined which includes the step of first moving the liquid surface to the pump inlet, maintaining the liquid surface at the pump inlet, and using the measurement of the gas pressure required to perform these steps as the means for determining the desired pressure. None of the references disclose this important means and method of calculating the pressure.

In new Claim 43 the applicant defines that series of steps which he has devised which will permit a measurement or calculation of the static pressure at any point below the liquid surface of a well, this claim defining the same subject matter as Claims 19 and 20 but setting forth the steps of first measuring the normal liquid level when the pump is not operating and the pressure at the casing head under these conditions, then closing the casing head and depressing the surface of the liquid to a new stable level, noting the casing head pressure to maintain the liquid at the new level, and then utilizing the difference in pressure and the difference in height of the fluid to calculate the desired information. These are physical steps not contemplated in any of the references and in the present form it is believed that Claim 43 is allowable.

The applicant has therefore provided the oil industry with a new novel and simple means for obtaining pressure information from a well containing a mechanical pump, this information being sub-

Defendant's Exhibit Q—(Continued)

stantially impossible to obtain before the applicant's invention. The use of pressure bombs or other pressure recording devices in wells of this character would only permit the measurement of the pressure at whatever level the pump might be located but did not provide a means for calculating the pressure at other points in the liquid. The applicant has therefore contributed an important and valuable advance in the oil art and it is believed that he is entitled to the full protection set forth in new Claims 39 through 43.

With regard to claims directed to the feature of determining the maximum potential capacity of the well, new Claims 44 and 45 constitute old Claims 21 and 22 rewritten in somewhat the same form as has been adopted for Claims 39 through 43, namely, setting forth the physical steps of the method invented by the applicant and summing up how the information obtained by these physical steps can be correlated and used to obtain the information desired.

In the rewriting of these claims care has been taken to avoid the objectionable features pointed out by the Examiner on Page 5 of the last Office action, while the specification has been amended to avoid the objectionable features pointed out on Page 3 of the last Office action.

As to the criticism in the first paragraph on Page 6, the Examiner's attention is called to the fact that with the information obtained by the physical steps recited in Claims 44 and 45 a ratio is determined

Defendant's Exhibit Q—(Continued)

which can then be used to compute the rate of production not only when the pump operates in its then location to reduce the pressure to zero at the pump inlet but the production may also be computed for some other new or possible location of the pump whereupon the operator of the well may determine that while his maximum production rate with the present location of the pump is a certain value, the well is capable of producing more oil should he lower the pump or raise the pump in order to obtain a better gas separation and hence a better volumetric efficiency from the pump. All of this is explained carefully in the specification and the expression "at other locations" is employed for the very purpose of preventing interpretation of these claims to mean that the results of the method will apply only to the then location of the pump.

In view of the fact that the references applied by the Examiner to Claims 21 through 25 are Pages 194 and 216 of the 1931 publication and Pages 152 and 153 of the 1933 publication, the Examiner's attention is called to the fact that again these publications refer only to "flowing" wells. Page 216 of the 1931 publication merely refers to a method of determining the density of the fluid in the "flowing" well between the lower end of the flow tubing and the point in the well at which the fluid is "likely" to be entering the well bore. The Examiner must remember that the density in a "flowing" well differs from the density of the annular space of a well

Defendant's Exhibit Q—(Continued)

being pumped in that the density increases from the lower end of the tubing to the point at which the fluid enters the well bore. This publication does not describe a method which can be applied to pumping wells nor does it disclose any information which added to the information contained in the 1933 publication to achieve the result obtained by the applicant.

However, it should be noted that new Claims 44 and 45 define the applicant's method as applied and limited to wells which contain a pump suspended upon tubing to further distinguish these claims from the "flowing" well methods. In the same manner Claims 23, 24 and 25 have been amended to limit them to wells containing pumps to distinguish these claims from "flowing" well methods such as those disclosed.

Pages 152 and 153 disclose only the steps of taking the static and the flowing pressures with a pressure bomb but do not include the steps which the applicant employs of utilizing the location of the liquid level at different points within the casing at different pressures within the casing for the purpose of determining and calculating the production capacity.

Claims 26 through 33, which are directed to the applicant's method of determining density in a well which contains a pump by employing the steps of changing the liquid level in the well and comparing the change in liquid level with the change in gas

Defendant's Exhibit Q—(Continued)

pressure required or resulting from the change in level, are not met by the disclosures contained in the pages of the 1933 publication. Page 150 of this publication merely described a method of calculating the static bottom hole pressure in artesian type wells by using a pressure bomb and thus to determine the density in the well and from this density he computes the pressure due to the fluid column. Why he does not take the static bottom hole pressure direct with the bomb is an unexplained mystery. However, regardless of the mystery, he does not disclose the use of the two levels and the difference in pressure necessary to maintain the liquid at these two levels as the means for determining the density of the fluid.

Again Page 216 of the 1931 volume does not disclose any method for obtaining the density under thhe conditions set forth by the applicant which employs using the two levels of liquid and the pressure necessary to maintain these levels.

The Examiner has rejected Claims 26 through 33 as covering the obvious way of measuring density. The applicant cannot agree with this rejection since prior to the introduction of this method into the industry by the applicant no one measured density by this method. As a matter of fact, no one knew how to determine the density of the liquid in a well which was being pumped and the oil industry has welcomed the applicant's method as being a simple and economical way in which to acquire information impossible to achieve before.

Defendant's Exhibit Q—(Continued)

The Examiner has rejected Claims 26 through 33 as unpatentable over Hay, Stancliffe or Field. Each of these references discloses a means for determining the density or specific gravity of a liquid in a tank which consists in positively inserting into the liquid at two different levels pressure measuring devices and then by computing from the information obtained the density of the liquid. The applicant is not claiming that he is the first to determine that the specific gravity of a liquid can be determined by taking pressure measurements at two different levels but he is claiming that he is the first to conceive and disclose the method of taking density measurements in an oil well having a pump which prevents the insertion of pressure measuring devices and he is claiming that he is the first to conceive and disclose that method which includes the changing of the liquid level by gas pressure and utilizing the information so obtained for the purpose of density computations. What the Examiner says is true; it would not amount to invention to divide the difference in the pressures at two locations by the distance between those locations but it does require invention to find out how to measure that pressure at the two locations for density measurements by using the steps set forth in the claims. If it were possible to readily take those measurements of pressure, the Examiner might have some argument but up to the present time no one other than the applicant has found an adequate method

Defendant's Exhibit Q—(Continued)

of measuring the density of the liquid in an oil well having a pump and he is therefore entitled to full protection upon his advance in this art.

The specification has been amended to more clearly bring out the fact that the density determination may be determined while the pump is being operated by the insertion made on Page 25 at Line 2. It was believed, however, that the original specification made it obvious that all of the measurements referred to in the specification, with the exception of the static pressure measurement, were to be accomplished while the pump was running since the primary object of all of the methods disclosed herein is to permit the various measurements to be taken without requiring removal of the pump parts and without requiring interruption in the production from the well.

Claim 33 has been corrected to avoid the rejection of incompleteness by stating in the next to the last line that the comparison is made with the "difference" between the pressures.

The Examiner has rejected Claims 35 through 38 as involving new matter. Such rejection is believed to be incorrect. On Page 19 of the original specification it was stated how by using the pump to change the liquid level the production capacity of the well could be calculated, the pressures referred to on that page being the pressures at the pump inlet which is "a known location" and includes not only the pressure of the gas upon the surface of the liquid but also the computation of the pressure exerted by

Defendant's Exhibit Q—(Continued)

the weight of the liquid column above the pump inlet. Again on Page 20 it is stated that by changing the production rate of the pump and comparing the fluid pressure at the pump inlet under the two conditions of production the production capacity of the well may be determined. It follows therefore that, as explained on Pages 19 and 20, by utilizing two pressures at the pump inlet and comparing the difference in these pressures with the difference in the liquid levels in the well under the two pressure conditions, the production rate may be calculated. In wells having substantially no gas pressure the computation of the pressure at the pump inlet consists merely in determining where the fluid level is and computing the effect in pressure of the column of liquid above the pump inlet. This represents pressure at the pump inlet. Again when the liquid level has been changed, still under the condition of little or no gas pressure, the pressure at the pump inlet is computed by computing the pressure value of the liquid column now above the pump inlet.

The applicant has disclosed the method of determining the production capacity by comparing two pressures at the pump inlet with two conditions of liquid surface level and he is entitled to a claim covering this, whether the computation of the pressure includes a zero gas pressure or some gas pressure above zero.

Further, on Pages 17 and 18 is clearly disclosed

Defendant's Exhibit Q—(Continued)

the manner in which the applicant may utilize the information acquired by the method set forth in Claims 35 through 38 to determine the rate of production for zero pressure or any other pressure between zero and the actual pressure at the pump inlet, zero pressure at the pump inlet representing operation of the pump at such rate as will draw the liquid out of the well as fast as it flows in.

It is believed that those portions of the specification hereinabove referred to clearly disclose (a) the manner in which the capacity of a well may be determined by comparison of the pressures due to the liquid columns where gas pressure is zero; (b) the manner in which the capacity of the well can be determined by merely comparing the two liquid levels when the gas pressure is zero; (c) the manner in which the rate of production for any pressure between zero and actual pump inlet pressure with the pump in its then location and rate of production.

The rejection of Claim 38 on the ground of involving new matter is believed to be unwarranted in view of the fact that on Pages 16 and 17 of the specification is disclosed a method of determining the pressure at the pump inlet and from that calculating the pressure at any other level. Other portions of the specification as referred to herein describe the manner in which utilization of the pressures so obtained can be employed for the purpose of calculating the production capacity. Whether these pressures are calculated for the pump inlet or for some other known or fixed location below the

Defendant's Exhibit Q—(Continued)

surface of the liquid is immaterial so long as the applicant has disclosed the manner in which such computations of pressures at the other locations can be determined.

The Examiner has rejected Claims 36 and 37 as unpatentable over Lehr of record. The applicant fails entirely to understand this rejection since the applicant is not claiming merely the use of the Lehr device to determine the rates of the liquid levels under two rates of production but has disclosed a complete method for determining production capacity not contemplated and not taught in the Lehr patent and which as one of its steps involves the location of the liquid level. If the Examiner repeats this rejection, further explanation is requested.

The Examiner's classification of Claims in groups I and II is noted. The applicant cannot understand, however, how the Examiner allocates the various claims to these two groups. This entire group, Claims 21 through 25 and 35 through 38, are directed to the method of determining the maximum production capacity of the well which includes comparing two pressures at the pump inlet under two operating conditions of production from the well as, for example, comparing the static or non-producing pressure with the pressure at a normal production rate while others of the claims specify two producing rates, normal and a "reduced" rate.

Claim 24 is believed to be generic in that it specifies the comparison of the pressure at "one rate of production" with the pressure at the pump inlet

Defendant's Exhibit Q—(Continued)

for a "changed" rate of production. This will read upon both Figs. 5 and 6 since "zero production rate" gives and must be considered as "a production rate". It is therefore believed that the applicant has presented generic claims and is therefore entitled to specific claims to two species or two forms of the method disclosed. Reconsideration of the requirement that the applicant restrict specific claims to only one species is therefore requested.

In making the foregoing amendment a sincere effort has been made to meet each of the Examiner's rejections and objections in order to expedite the prosecution of this application and it is believed that upon reconsideration of this application all of the claims will be found to be allowable.

Respectfully submitted,

HAROLD W. MATTINGLY
Attorney for Applicant

HWM:MM

Defendant's Exhibit Q—(Continued)

12

February 8, 1939

In re application of:
Cranford P. Walker
Ser. No. 171,170
Filed Oct. 26, 1937
For: Method of Determining Fulid Density, Fluid Pressure and the Production Capacity of Oil Wells

Examiner, Division 36:

Division has been required under Rule 41 between:

I. Claims 24, 25, 35, 36, 44 and
II. Claims 23, 37, 38, 45.

There appear to be no generic claims, the remaining claims in the case, 26-33 and 39-43, being subgeneric, and claims 12-17 being retained under Rule 42.

The groups cover mutually exclusive species and division is approved, pending the non-allowance of a generic claim.

Respectfully,

MARK L. WHITNEY
Examiner of Classification

BEL
BEL:af

Defendant's Exhibit Q—(Continued)
Mail Division Feb. 11 1939 U. S. Patent Office.
In the United States Patent Office

Cranford P. Walker

Method of Determining Fluid
Density, Fluid Pressure, and
the Production Capacity of
Oil Wells

Filed October 26, 1937
Serial No. 171,170

PETITION TO MAKE APPLICATION SPECIAL

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Now comes your petitioner, by his attorney of record, and requests that this application be made special for examination, and that the Examiner in charge thereof be instructed to take this application up for action out of its regular turn.

Your petitioner avers that he is engaged in the business of making surveys of oil wells, particularly wells containing mechanical pumps for pumping the oil to the ground surface, this business consisting essentially in obtaining information as to the pressure existing in the liquid in the well at any desired point below the surface of the liquid, the determination of the density of the oils in any particular well under measurement and in the determination of the maximum possible production capacity (known as

Defendant's Exhibit Q—(Continued)

potential) of the well, all of which information is obtained by applicant without the necessity of interruptnig normal production from the well and without the necessity of removing the pump, pump tubing, or any of the mechanical pump parts.

That applicant's method as set forth in the above entitled application and as claimed therein has met with instant commercial success and is now adopted for standard practice by the major oil companies of the United States, and was welcomed by the oil industry in solving a problem that has vexed the industry until applicant's solution therefor was presented.

Your petitioner avers further that, prior to his introduction into this field of his method and apparatus as described and claimed in this application, there was no other similar method and process known in this field and that, subsequent to his introduction of this method and process, a competitor inspected and studied applicant's process and thereafter entered competition with your petitioner employing oil well survey devices including means for producing pressure waves in the oil wells, mechanism for recording the echoes from the obstructions in the well, mechanism for tuning or accenting the echoes from the tubing collars, and the competitor is practicing the methods and processes for obtaining liquid pressures, densities and production capacity of the wells by steps of measuring liquid levels, depressing the liquid surfaces by the employment of different pressures of gases and by employing dif-

Defendant's Exhibit Q—(Continued)

ferent rates of production from the well in the manner described and claimed in this application.

That the manner in which the competitor is conducting the competing business is such that not only applicant but the public are subject to great damage and injury and possible loss of the benefits of applicant's invention which can be saved if the business can be conducted and controlled by proper patent protection and controlled licensing.

That the petitioner further avers that until the patent is granted he is helpless to prevent this destructive competition.

That your petitioner further avers that he has actively and diligently prosecuted this application by promptly amending the application as soon as copies of the cited publication could be obtained, and further attempted to have this application considered in a personal interview for the purpose of expediting the early issue of the patent.

Your petitioner further avers that both he and his attorney of record have diligently searched the prior art and in the opinion of his attorney of record each and every of the claims now presented in this application is patentable.

That, in the opinion of his attorney, the competitor is infringing all of the claims now presented in this application.

That attached hereto are affidavits verifying the statements made in this petition, including an affidavit by your petitioner Cranford P. Walker, an

Defendant's Exhibit Q—(Continued)

affidavit by his attorney of record, Harold W. Mattingly, an affidavit by Ernest K. Parks, a petroleum engineer, an affidavit by Walton E. Gilbert, equipment engineer of the Shell Oil Co., an affidavit by Elwin B. Hall of the Hall-Baker Co., and an affidavit of R. L. Keyes of The Texas Company (Calif.)

Respectfully submitted,

CRANFORD P. WALKER

By HAROLD W. MATTINGLY

His Attorney.

Washington, D. C.,
February 11, 1939.

Mail Division Feb 11 1939 U. S. Patent Office.

In the United States Patent Office

Cranford P. Walker

Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells

Filed October 26, 1937
Serial No. 171,170

AFFIDAVIT OF CRANFORD P. WALKER

Cranford P. Walker, being duly sworn, deposes and says that he is the inventor named in the above-entitled application for United States Letters Patent.

That he is actively engaged in the business of making oil well surveys to determine the pressures

Defendant's Exhibit Q—(Continued)

below the oil surface, the densities of the oil in wells and the maximum production capacity of oil wells.

That as soon as he introduced his method of obtaining this information as set forth and claimed in the above-entitled application, the same was welcomed by the oil industry and has met with great commercial success as evidenced by the attached list, marked Exhibit B, of companies that have employed him to make these surveys on their wells.

That, prior to his introduction to the oil industry of the methods described and claimed in this application, applicant's methods and processes were not known to the oil industry as is verified in the attached affidavits of Ernest K. Parks, Walton E. Gilbert, Elwin B. Hall and R. L. Keyes.

That, after applicant introduced to the oil industry the methods described and claimed in this application, representatives of a competitor, International Geophysics Inc., then not engaged in a similar line of activity, came to oil wells on which applicant was practicing his methods and inspected the same and made photographs of applicant's apparatus and, subsequent thereto, the competitor, International Geophysics Inc., entered into direct competition with applicant employing apparatus including sonic echo instruments similar to applicant's for obtaining fluid level measurements in the well and employing method and process steps for obtaining liquid pressure, density and maximum production capacity measurements identical with the methods and processes described and claimed in this application.

Defendant's Exhibit Q—(Continued)

That applicant has personally watched the competitor's tests of oil wells and, from the activities he observed, the charts he has inspected and information furnished to him, he believes that the methods and processes employed by the competitor constitutes an infringement of each and every of the claims now presented in this application.

That the competitor, International Geophysics Inc., is competing with applicant in such manner as to constitute unfair competition with applicant, and the competitor has seriously injured applicant's business and threatens to continue such injury in a manner which may result in the destruction of applicant's business.

That until the said application matures into a patent, he is helpless to prevent said competition and and damage to his business.

That he has carefully inspected the article published in the Petroleum World of February, 1938, constituting Exhibit A, attached to the accompanying affidavit of Harold W. Mattingly and made a part hereof, and that the methods described as practiced by the competitor in that article constitute in his opinion and in the opinion of his legal counsel, an infringement of each and every of the claims now presented in the said application.

That he has personally inspected the apparatus and methods practiced by the said competitor and in his opinion the methods actually practiced by the competitor constitute an infringement of each and

Defendant's Exhibit Q—(Continued)

every of the claims now presented in this application.

That he has caused to be made a thorough search of the prior art, both as to patents and publications, and that in his opinion and in the opinion of his legal counsel, each and every of the claims of the said application are patentable to him.

CRANFORD P. WALKER

Sworn to and subscribed before me this 11th day of February, 1939.

FREDERICK A. ALLMETT
Notary Public.

WELLS TESTED BY DEPTHOGRAPH UNIT

Company	Total No. of Wells	First Well Tested Date
Abrams & Associates	1	May 29, 1937
Ajo Oil Company	1	Sept. 2, 1938
W. P. Andrews Oil Co.	2	Oct. 25, 1938
Apex Petroleum Corp.	3	Nov. 4, 1937
Arrowhead Oil Co.	5	July 3, 1937
Associated Oil Co.	2	Feb. 19, 1937
Axis Petroleum Co.	2	Jan. 20, 1939
Bachmann Petroleum Co.	1	[illegible] 18, 1937
Bankline Oil Co.	10	Oct. 14, 1936
Barnsdall Oil Co.	10	Nov. 11, 1936
Alphonso E. Bell	5	Dec. 1, 1936
Beloil Corp.	1	June 26, 1936
Bolsa Chica Oil Corp.	1	Feb. 15, 1938
Boswell Petroleum Co.	1	June 24, 1938
Calridge Oil Co.	2	Oct. 11, 1938
Chanslor-Canfield & Midway Oil	22	Feb. 18, 1937
Cities Service Co. (Hobbs, N. M.)	1	Dec. 15, 1938
Continental Oil Co.	12	Nov. 27, 1936

Defendant's Exhibit Q—(Continued)

Company	Total No. of Wells	First Well Tested Date
Continental Oil Co. (Hobbs, N. M.)	10	Dec. 16, 1938
Colorado Oil Co.	7	June 25, 1937
Crude Oil Drilling Co.	1	Aug. 1, 1938
Davis Investment Co.	2	April 27, 1936
Dearborn Oil Co.	1	July 12, 1937
Dougan Drilling Co.	1	Aug. 25, 1938
O. C. Field Gasoline Corp.	24	Jan. 24, 1938
G & B Oil Co.	1	Sept. 3, 1938
Gibson Oil Co.	6	Mar. 18, 1937
Graham-Loftus Oil Co.	1	Aug. 6, 1938
Greathouse Oil Co.	1	Aug. 25, 1938
Gypsy Oil Co.	1	July 19, 1938
General Petroleum Corp.	2	June 22, 1937
Hammil Oil Corp.	1	Oct. 1, 1938
Hancock Oil Co.	3	April 13, 1937
Hampshire Oil Co.	1	Aug. 2, 1938
Hathaway Co.	4	June 8, 1938
Hilldon Oil Co.	13	April 5, 1937
Hogan Petroleum Co.	9	June 23, 1938
Honolulu Oil Co.	11	Sept. 1, 1936
Iris Oil Co.	1	Oct. 13, 1938
J. E. F. Oil Co.	1	July 5, 1938
A. S. Johnston Drilling Corp.	8	Feb. 1, 1938
Kobe Inc.	2	April 14, 1938
Kettleman North Dome Assn.	4	May 23, 1938
Lido Petroleum Co.	1	May 27, 1938
Like Petroleumn Corp.	1	June 10, 1938
Lubrite Oil Co.	1	Mar. 24, 1938
A. N. Macrate Co.	1	April 21, 1938
MacDonald & Burns	5	Aug. 23, 1938
MacMillan Petroleum Corp.	3	Mar. 19, 1938
Morton & Elder Oil Co.	2	Feb. 21, 1938
Moyle Petroleum Co.	1	May 6, 1938
McVicar-Rood Co.	4	Sept. 27, 1937

Defendant's Exhibit Q—(Continued)

Company	Total No. of Wells	First Well Tested Date
North American Oil Consolidated	3	May 4, 1937
O'Donnell Oil Co.	3	Aug. 31, 1937
The Ohio Oil Co.	3	Mar. 18, 1938
Oil Incorporated	1	Feb. 3, 1937
Orco Oil Co.	1	May 11, 1938
Otis Hoyt	2	Feb. 17, 1937
Olympic Refining Co.	3	Oct. 14, 1937
Pacific Western Oil Corp.	40	April 23, 1936
J. Perl Oil Co.	1	Nov. 15, 1938
Pima Oil Co.	1	April 2, 1938
The Petroleum Co.	1	April 14, 1938
Petroleum Securities	1	Jan. 25, 1937
Petrol Corp.	38	Nov. 11, 1937
Phillips Petroleum Co.	1	Dec. 8, 1938
Republic Petroleum Co., Ltd.	5	May 10, 1938
Richfield Oil Corp.	13	Oct. 1, 1937
Rio Grande Oil Co.	4	Mar. 6, 1937
Royalty Service Corp., Ltd.	2	April 11, 1938
Shell Oil Co.	94	April 29, 1936
Signal Oil & Gas Co.	2	Aug. 12, 1937
St. Helens Petroleum Co.	4	April 9, 1938
Selbar Oil Co.	1	Feb. 7, 1938
Sheldon Oil Co.	2	June 10, 1938
Signal Petroleum Co.	1	Sept. 14, 1938
Thomas W. Simmons	3	Jan. 3, 1938
Sonwell Oil Co.	1	Sept. 27, 1938
South Basin Oil Co.	10	Aug. 19, 1937
Southern Calif. Drilling Co.	2	Oct. 11, 1936
Sovereign Oil Co.	1	May 21, 1936
Speik Petroleum Co.	1	May 27, 1938
Standard Oil Co. of Calif.	133	May 25, 1936
Sunset Oil Co.	16	Nov. 4, 1937
Sunshine Oil Co.	1	Feb. 12, 1938
Superior Oil Co.	1	Nov. 28, 1938
Termo Co.	6	May 11, 1938
The Texas Co.	37	Aug. 1, 1936

Defendant's Exhibit Q—(Continued)

Company	Total No. of Wells	First Well Tested Date
Union Pacific Railroad Co.	34	Sept. 23, 1937
Utah Oil & Drilling	1	June 24, 1938
Union Oil Co. of Calif.	123	May 8, 1936
Vesta Petroleum Co.	1	Sept. 23, 1938
Weber Butler Oil Co.	1	July 14, 1937
Western Gulf Oil Co.	5	Oct. 13, 1936
Western States Drilling Co.	1	Nov. 3, 1938
Wilshire Oil Co.	5	April 20, 1936
Woolner Oil Co.	4	June 13, 1938
C. F. Yunker	1	April 7, 1938
Zenith Oil Co.	1	July 19, 1938

Mail Division Feb 11 1939 U. S. Patent Office.

In the United States Patent Office

Cranford P. Walker

Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells

Filed October 26, 1937
Serial No. 171,170.

AFFIDAVIT OF HAROLD W. MATTINGLY

Harold W. Mattingly, being duly sworn, deposes and says that he is the attorney of record in the matter of the above-entitled application, filed by Cranford P. Walker, Serial No. 171,170, on October 26, 1937, for Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

Defendant's Exhibit Q—(Continued)

That, upon information and evidence furnished to affiant including an article published in Petroleum World of February, 1938, pp. 59-62, constituting an advertisement of the International Geophysics Inc., (copy of which is attached hereto and made a part hereof and marked "Exhibit A"), a competitor of the inventor, Cranford P. Walker, and including the affidavits of Ernest K. Parks, Walton E. Gilbert, Elwin B. Hall and R. L. Keyes, and information furnished by the inventor, Cranford P. Walker, affiant is informed and believes that, prior to the introduction into the oil fields by applicant of the methods and processes set forth in this application, the same was not known and that the competitor, International Geophysics Inc., after seeing and inspecting applicant's apparatus and methods, later produced apparatus and practiced methods as follows: mechanism for producing pressure waves in oil wells and for recording the echoes from different obstructions in the wells to determine the location of the liquid surface in the well and for accenting the echoes from certain of the obstructions, depressing or changing location of the liquid level in the well, and changing the rates of production from the wells to determine the pressures in the liquid, the density of the liquid and the maximum production capacity of the wells, and that, in affiant's opinion, these methods and this apparatus constitutes an infringement of each and every of the claims contained in this application.

Defendant's Exhibit Q—(Continued)

That he has caused to be made a thorough search of the prior art, both as to patents and as to publications, and, in his opinion, each and every of the claims now pending in the application is patentable to applicant.

HAROLD W. MATTINGLY

Sworn to and subscribed before me this 11th day of February, 1939.

FREDERICK A. ALLMETT
Notary Public.

Figure 1. How instrument for measuring fluid level is connected to the casinghead

Determining Pumping Well Performance

*By J. J. Jakosky**

FLUID LEVEL and bottom-hole pressure measurements are proving to be of great value in meeting the demand for more efficient oil recovery and in eliminating wasteful and inefficient pumping practices.[1] This paper reviews briefly the principles of oil recovery in pumping wells, and describes various applications of fluid-level measurements to production problems.

Since the flow of oil from the producing formation into the well is roughly proportional to the pressure difference, oil production is possible only when the pressure in the formation is higher than the pressure in the hole. This higher pressure in the formation forces the oil into the well and production will stop when the pressure in the well at the formation depth becomes equal to the formation pressure. The pressure at the bottom of the well is dependent largely upon the height of fluid. The maximum oil production under ordinary conditions is obtained when the lowest possible fluid level can be maintained. This makes the operating fluid level, therefore, of great importance. The accurate determination of the operating fluid level in a pumping well can be obtained in general by use of two different methods: (a) recording bottom-hole pressure gauges, or (b) fluid level measurements.

Bottom Hole Pressure Gauges

The bottom-hole pressure gauge is fastened usually below the pump, and thereby records the total pressure existing at that depth. These recording gauges have two essential parts: a pressure element open at the bottom end to the pressure to be recorded and a clock-driven chart drum or carriage. A stylus attached to the free end of the pressure element records its movement on sensitized paper or metal sheets affixed to the chart drum or carriage. This whole mechanism is enclosed by a suitable case. At the conclusion of a run the chart record is recovered when the instrument is pulled from the well. Pressures at various times of the test are determined by comparing the recorded pressure stylus movement with pressure calibration curves of the instrument.

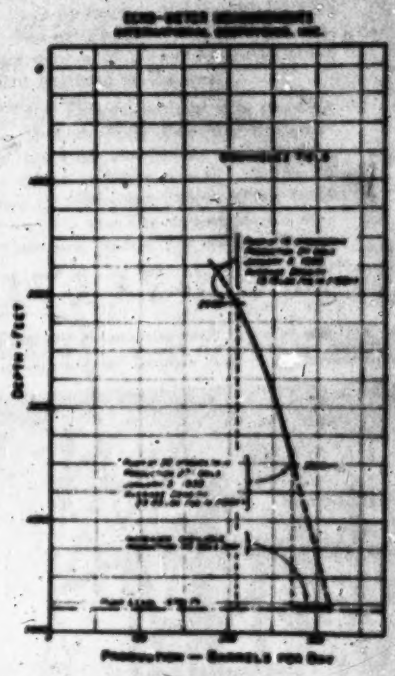
To obtain bottom-hole measurements with instruments of this type it is necessary to pull the rods and at times even the tubing in order to lower the instrument to the well bottom, where the readings are made over the desired period of time. The recording must be made over a sufficient period of time to insure that equilibrium conditions have been reached after the shut-down period preceding installation of the bottom-hole gauge. After completion of the recording, the rods (or rods and tubing) are again pulled in order to recover the instrument with its data. The recorded data are then available for analysis and proper guidance of the subsequent pumping operations. The cost or rental charge for the instrument, the loss of oil production during the two periods the well is shut down when installing and recovering the gauge, and the cost and hazard of the two pulling jobs, are all directly chargeable to the cost of obtaining these data.

Instruments for Measuring Fluid Level

The second method (as exemplified by the Echo-Meter) measures the operating fluid level while the well is pumping, and without pulling either rods or tubing. These measurements can be made at different rates of production or at different casinghead pressures, and the bottom-hole pressures calculated. As most wells are equipped with a gate valve, plug cock or a ball-plug in the casinghead, it is a comparatively simple job to connect the Echo-Meter instrument to the casinghead, as shown in Fig. 1. The component parts of the Echo-Meter are a highly sensitive microphone, a special cartridge to initiate a very steep-front sound wave, vacuum tube amplifier and recording camera, the necessary valves and a gauge to show the gas pressure in the casinghead. The instrument is connected to the recording truck by a shielded cable.

When the cartridge is fired, a steep-front sound wave is sent into the casinghead. This sound wave moves down the annular space between the tubing and casing at a speed which varies with the gas composition. Under California conditions the speed may vary from 850 to 1600 feet per second in different wells. The speed has been found to be practically constant throughout the entire length of any one well. As the sound wave travels down the well it is gradually absorbed and partially reflected by any obstructions encountered. Small reflections are generated by tubing collars and travel back up the casing to the instrument. Tubing catchers and liner tops send back much stronger reflections. The fluid oil surface reflects practically the whole wave front which has traveled to the bottom of the well. When these reflections return to the instrument, they are picked up by a special microphone which generates a variable but minute electric current that is conducted by the cable to the recording truck. Here the small current is

*Method and Apparatus patents pending.



171170

Exhibit A.

104R

*Technical Director, International Geophysics, Inc., Los Angeles.

[1] Stanley Herold, "Present Status of Bottom Hole Pressure Work," California Oil World, Aug. 23, 1954.
D. L. Katz and W. H. Barlow, "Relation of Bottom Hole Pressure to Production Control," A.P.I. Drilling and Production Practice, 1955.
H. K. Ihrig, "Bottom Hole Pressure Bomb Aids in Stimulation of Equipment for Wells," Oil and Gas Journal, October 17, 1955.

THE Electrical

ECHO-METER

for accurate fluid level determinations

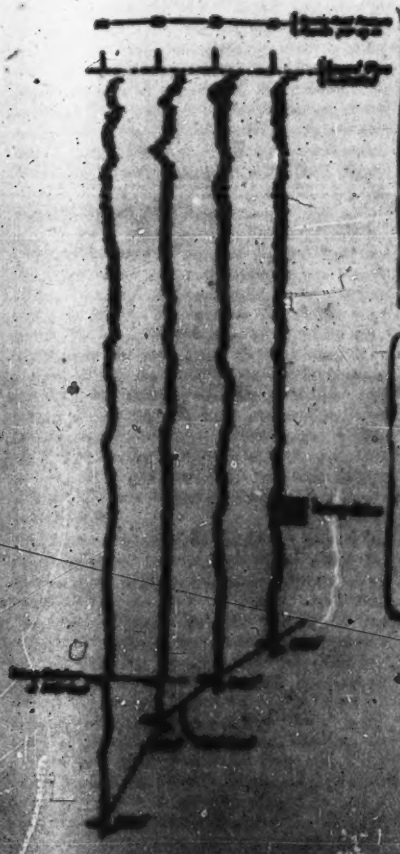
Fluid Level Determinations furnished by *ECHO-METER*† are of great value in *decreasing the cost of pumping* and in observing the *producing characteristics* of the well. The accuracy and rapidity of *ECHO-METER* measurements plus the low cost of this service account for the ever-increasing use of Fluid Determinations. All of this information is obtained without excessive pumping speeds or dangerous production rates which usually are harmful to the well.

From *ECHO-METER* Determinations it is possible to accurately compile Bottom Hole Pressure information which shows the operating conditions in the well—determine Potentials which indicate a well's ability to produce—compute the Productivity Index which indicates changes in production and the causes therefor—obtain the Proper Pumping Speed for most efficient oil recovery, etc.

† Trademark

171170 105 R

IGI



for a second measurement after equilibrium conditions had been established. On January 4, 1938, another [illegible] fluid level measurement was made. The level was then found to be at 3000 feet, or 2000 feet above the pump, and the well was producing 211 barrels per day. These data are plotted in Fig. 2. By extrapolating the values it is indicated that there is available a gross production of about 316 barrels per day, which is 45 barrels per day more than previously had been assumed. This available increase in production is obtainable by increasing the pump displacement, either by speeding it up or by replacement with a larger-sized pump.

Determining Fluid Density and Bottom-Hole Pressure

The [illegible] process is of considerable importance in determining the operating conditions in a well. One convenient way to determine the static bottom-hole pressure of the casing is to measure the changes in fluid level at different pump pressures. This may be done by building up the casinghead pressure by opening the gas through a high-pressure regulator and measuring the resulting increased fluid levels in the well at different gas pressures. The bottom-hole pressure at the pump equals the weight of the fluid column down to the pump + (the weight of the gas column) + (the casinghead pressure). This may be illustrated by the following data:

In Fig. 3 are shown four separate fluid level measurements made on a well in the Los Angeles Basin. Reading right to left, the measurements are first, second, third and fourth. Considering them in order: The first was recorded with a casinghead pressure of 20 lbs./square inch and the fluid level was found to be at 3700 feet. The second recording, made after equilibrium had again been reached, was with a pressure of 30 lbs./square inch with the fluid level at 3185 feet. The third record shows that with 40 lbs./square inch the fluid level was found down below the tubing socket (which is at a known depth of 3301 feet) to a level of 3404 feet. The fourth recording was made at 45 lbs./square inch with the fluid level measured at 3777 feet. Throughout this series of measurements the well's production was an unvaried amount.

The fluid level is measured in equilibrium with the real pressure existing down in the pump; pressure is equal to the weight of the gas column plus the casinghead pressure. The weight of the gas column by distance is determined by the specific gravity of the gas and by the temperature of the column. The weight of the fluid column down to the pump equals the bottom-hole pressure minus the weight of the gas column.

Echo-Meter Measurements

Petroleum Engineering
Reel 171170
106

INTRODUCING
the Electrical
ECHO-METER
for accurate fluid level determinations

Location of the fluid level in a pumping well is of vital importance for get maximum production and greatest pumping efficiency. It is necessary to maintain the proper fluid level. Whenever changes take place which interfere with a low fluid level, there's the oil down to efficient wells, a Echo-Meter, an accurate, up-to-the-minute fluid level measurement can save the hundreds of dollars and at a small cost. Without shutting down the pump, pulling the rods or tubing or installing any well equipment, in one step a location of the fluid level is obtained, by sounding on a thin line attached to a "Echo Meter Meter" to reveal how the pumping level is the fluid level above. In addition to the information from the fluid level, other conditions are disclosed from casing valves, tubing valves, flow lines, etc., providing a complete picture.

ECHO-METER CAN BE USED

IIGI

in fluid level at equilibrium conditions. Due to changes in solubility of gas in oil and also the change in volume of the gas with a change in pressure, the fluid density varies from a maximum value at the bottom of the column, to a minimum value at the top of the column. By analyzing the first fluid level determination, it will be seen that an increase of 10 lbs. gauge pressure depressed the fluid level 100 feet, which is equivalent to a column density of 9.2* lbs./ square inch/100 feet of fluid height. $\frac{10 \text{ lbs.}}{109 \text{ ft.}} = \frac{9.2 \text{ lbs.}}{100 \text{ ft.}}$

The next pressure increase of 32 lbs. depressed the liquid about 220 feet, indicating a density of approximately 14.5 lbs./square inch/100 feet. The following 64 lb. increase found gas level down 220 feet giving a density of 14.75 lbs./ square inch/100 feet. From these calculations it is apparent that above 20 lbs./square inch gauge pressure, the density in this particular well changes slowly and the most practical purposes can be considered down to the pump. A density of 14.75 is not abnormal to wells making a fair amount of gas. Solid gasless fluid in this well would have a density of about 35 lbs./square inch/100 feet.

In Fig. 4 is plotted the fluid-level heights for this well in the Los Angeles Basin versus the total pressure; using a gas column weight of 10 pounds as the upper fluid level of 3000 feet. This graph indicates that the pressure at the pump is 995 pounds per square inch. In order for the oil in the formation to flow into this well, it must overcome this back pressure of 995 lbs./square inch. For the most efficient oil recovery, the bottom-hole pressure should be reduced as much as possible, and this can be achieved to a large extent by maintaining the lowest practical fluid level. After making changes in pump speed or capacity it is well to run a subsequent fluid-level measurement to be certain that the pump-down is being obtained.

Productivity Index and Well Performance

From the fluid level measurements additional important operating and production data can be obtained. Since the chief function of production oil companies is to work for more efficient oil recovery, the productivity index is of great importance.

The productivity index, defined as "the barrels per day of gross fluid produced per pound per square inch pressure drop at a specific subsurface datum", has proved to be an important factor in determining the productivity of a well. From data secured by use of the bottom-hole pressure gauges described in the early part of this article, a well's productivity index can be obtained by use of either of the following formulas:

(1) Productivity index = $\frac{\text{Gross rate} - \text{Clean rate}}{\text{Producing pressure} - \text{Producing pressure, Clean rate}}$

(2) Productivity index = $\frac{\text{Gross rate} - \text{Clean rate}}{\text{Static pressure} - \text{Producing pressure}}$

When using the bottom-hole fluid level measurements, the productivity index can be obtained substantially by use of the formula:

(3) Productivity index = $\frac{\text{Gross rate} - \text{Clean rate}}{\text{(Producing fluid level} \times \text{fluid density)} - \text{(Producing fluid level} \times \text{fluid density)}}$

The productivity fluid height results when the elevation of the fluid level above the pump

Gross rate — Clean rate

Producing pressure — Producing pressure, Clean rate

above datum, but in this case it is more convenient to use the fluid height above the pump. By applying formula (3) to the data from the

Gross rate — Gross rate

(Producing fluid height × fluid density) — (Producing fluid height × fluid density)

Productivity will plotted in Fig. 5 we obtain productivity index at various

Pump Elevation

Fluid Level

Producing fluid height at this Pump Elevation

Clean rate

Producing rate of oil emulsion at the above pump elevation

171170

10本

171170

108 R

Defendant's Exhibit Q—(Continued)

Application Div. Feb. 10 '39 U. S. Patent Office
Mail Division Feb 11 1939 U. S. Patent Office.

State of California
County of Los Angeles—ss.

AFFIDAVIT OF ERNEST K. PARKS

Ernest K. Parks, being duly sworn, deposes and says:

That he is engaged in the practice of petroleum production engineering; that in connection with studies of pumping wells in which mechanical pumps are employed for lifting the oil to the ground surface, it is necessary for him to have information as to the pressure at the pump inlet or at other levels below the liquid surface in the well; that it is desirable for him also to know the density of the fluid in the well and it is desirable for him to determine the production capacity or possibility of the wells operated by the various owners or operators; that he has advised his employers to use, and that they have used, the Depthograph Company to make tests and measurements on at least twenty wells to determine the pressures, densities and production capacities as stated above.

That he is personally acquainted with the inventor, Cranford P. Walker, and is familiar with the methods and apparatus employed by Cranford P. Walker on behalf of the Depthograph Company.

That previous to the introduction to the oil industry by Cranford P. Walker of the sonic method

Defendant's Exhibit Q—(Continued)

of obtaining pressures, densities and production capacity in oil wells, the only method which affiant knew to obtain measurements of the pressure in wells pumping below the level of the fluid therein, was by the use of pressure recorders which were required to be lowered into the well to the desired depth below the level of the oil in the well, which procedure necessitated the removal of at least the sucker rods of the pumping equipment and frequently required the removal of the pump tubing from the well, the attachment of the pressure bomb and the reinsertion of the previously removed pump tubing and/or sucker rods to locate the pressure bomb at the desired level, after which it was necessary to again remove the sucker rods and/or pump tubing to bring the recorder to the ground surface for inspection and reading, all of which operations necessitated stopping of production from the well, both for the purpose of inserting the pressure ~~bomb~~ recorder and for removing the pressure ~~bomb~~. This method produced only information as to the pressures at the pump inlet and did not furnish any information relative to fluid density or the character of the fluid, as regards the relation between the fluid and gas entrapped therein, which was being pumped from the well.

That prior to the introduction to the oil industry of the Walker method there was, to affiant's knowledge, no practicable way in which this fluid density and fluid character could be ascertained.

Defendant's Exhibit Q—(Continued)

That prior to the introduction of the Walker method the only way, to affiant's knowledge, to calculate production capacity of pumping wells was with the use of pressure recorders which required interruption of the production of the well for their insertion and removal as aforesaid.

That the use of the Walker method of obtaining pressure, density and production capacity has greatly facilitated the solution of the problem which to affiant's knowledge petroleum engineers have long been seeking an answer.

That to affiant's personal knowledge the Walker method as aforesaid has saved much time and appreciable expense in determining the information referred to herein.

That affiant first learned of the Walker method of obtaining pressure information, density information and production capacity in pumping wells on or about February, 1936, and this method was employed on wells to his knowledge in Huntington Beach, Montebello, Seal Beach, and Inglewood.

ERNEST K. PARKS.

Subscribed and sworn to before me, this 3rd day of February, 1939.

(Seal) BERNICE VAN GILSE

Notary public in and for the County of Los Angeles, State of California.

My Commission Expires Dec. 10, 1939

Defendant's Exhibit Q—(Continued)
Application Div. Feb 10 '39 U. S. Patent Office.
Mail Division Feb 11 1939 U. S. Patent Office.

State of California
County of Los Angeles—ss.

AFFIDAVIT OF WALTON E. GILBERT

Walton E. Gilbert, being duly sworn, deposes and says:

That he is employed by the Shell Oil Company in the capacity of equipment engineer; that in connection with pumping wells operated by his company in which mechanical pumps are employed for lifting the oil to the ground surface, it is desirable for him to have information as to the pressure at the pump inlet or at other levels below the liquid surface of the well; that it is desirable for him also to know the density of the oil in the well and it is desirable for him to determine the production capacity or possibility of the wells operated by the Shell Oil Company; that the Shell Oil Company has employed the Depthograph Company to make tests and measurements on at least 89 wells to determine the pressures, densities and production capacities as stated above.

That he is personally acquainted with the inventor Cranford P. Walker and is familiar with the methods and apparatus employed by Cranford P. Walker on behalf of the Depthograph Company.

That previous to the introduction to the oil industry by Cranford P. Walker of the sonic method of obtaining pressures, densities and production ca-

Defendant's Exhibit Q—(Continued)

pacity in oil wells, the only method which affiant knew to obtain measurements of the pressure in pumping wells below the level of the fluid therein was by the use of pressure bombs and pressure recorders which were required to be lowered into the well to the desired depth below the level of the oil in the well, which procedure necessitated the removal of at least the sucker rods of the pumping equipment and frequently required the removal of the pump tubing from the well, the attachment of the pressure bomb and the reinsertion of the previously removed pump tubing and/or sucker rods to locate the pressure bomb at the desired level, after which it was necessary to again remove the sucker rods and/or pump tubing to bring the recorder to the ground surface for inspection and reading, all of which operations necessitated stopping of production from the well both for the purpose of inserting the pressure bomb and for removing the pressure bomb.

That prior to the introduction of the Walker method the only way, to affiant's knowledge, to obtain production capacity of gassy pumping wells was with the use of pressure bombs which required interruption of the production of the well for their insertion and removal as aforesaid.

That the use of the Walker method of obtaining pressure, density and production capacity has aided materially in solving the problem for which, to affiant's knowledge, petroleum engineers have long been seeking a solution.

Defendant's Exhibit Q—(Continued)

That affiant first learned of the Walker method of obtaining pressure information, density information, and production capacity in pumping wells on or about October 2, 1936, and this method was employed on wells of this company located in California.

WALTON E. GILBERT.

Subscribed and sworn to before me this 3rd day of February, 1939.

(Seal) M. M. BROWN

Notary Public in and for the County of Los Angeles, State of California

My Commission Expires June 8, 1942

Application Div. Feb 10 '39 U. S. Patent Office.
Mail Division Feb 11 1939 U. S. Patent Office.

State of California
County of Los Angeles—ss.

AFFIDAVIT OF EDWIN B. HALL

Elwin B. Hall, being duly sworn, deposes and says:

That he is employed by The Hall-Baker Co. in the capacity of President; that in connection with pumping wells operated by his company in which mechanical pumps are employed for lifting the oil to the ground surface, it is necessary for him to have information as to the pressure at the pump inlet or at other levels below the liquid surface of

Defendant's Exhibit Q—(Continued)

the well; that it is desirable for him also to know the density of the oil in the well and it is desirable for him to determine the production capacity or possibility of the wells operated by The Hall-Baker Co.; that The Hall-Baker Co. has employed the Depthograph Company to make tests and measurements on at least 30 wells to determine the pressures, densities and production capacities as stated above.

That he is personally acquainted with the inventor Cranford P. Walker and is familiar with the methods and apparatus employed by Cranford P. Walker on behalf of the Depthograph Company.

That previous to the introduction to the oil industry by Cranford P. Walker of the sonic method of obtaining pressures, densities and production capacity in oil wells, the only method which affiant knew to obtain measurements of the pressure in pumping wells below the level of the fluid therein was by the use of pressure bombs and pressure recorders which were required to be lowered into the well to the desired depth below the level of the oil in the well, which procedure necessitated the removal of at least the sucker rods of the pumping equipment and frequently required the removal of the pump tubing from the well, the attachment of the pressure bomb and the reinsertion of the previously removed pump tubing and/or sucker rods to locate the pressure bomb at the desired level, after which it was necessary to again remove the sucker rods and/or pump tubing to bring the recorder

Defendant's Exhibit Q—(Continued)

to the ground surface for inspection and reading, all of which operations necessitated stopping of production from the well both for the purpose of inserting the pressure bomb and for removing the pressure bomb. This method only produced information as to the pressures at the pump inlet and did not furnish any information relative to fluid density or the character of the fluid, as regards the relation between the liquid and gas entrapped therein, which was being pumped from the well.

That prior to the introduction to the oil industry of the Walker method there was, to affiant's knowledge, no way in which this fluid density and fluid character could be ascertained.

That prior to the introduction of the Walker method the only way, to affiant's knowledge, to obtain production capacity of pumping wells was with the use of pressure bombs which required interruption of the production of the well for their insertion and removal as aforesaid.

That the use of the Walker method of obtaining pressure, density and production capacity has solved the problem which to affiant's knowledge petroleum engineers have long been seeking a solution.

That to affiant's personal knowledge the Walker method as aforesaid has saved great quantities of time and appreciable expense in determining the information referred to herein.

That affiant first learned of the Walker method of obtaining pressure information, density information

Defendant's Exhibit Q—(Continued)

and production capacity in pumping wells on or about Sept. 23, 1937 and this method was employed on wells operated by this company located at Wilmington Oil Field, California.

ELWIN B. HALL

Subscribed and sworn to before me this 2nd day of February, 1939.

(Seal) M. M. COLBURN

Notary Public in and for the County of Los Angeles, State of California.

My Commission Expires February 25, 1940

Application Div. Feb. 10, '39. U. S. Patent Office.
Mail Division, Feb. 11 1939. U. S. Patent Office.

State of California,
County of Los Angeles—ss.

AFFIDAVIT OF R. L. KEYES,

being duly sworn, deposes and says:

That he is employed by The Texas Company (Calif.) in the capacity of Assistant Manager of the Producing Department; That in connection with pumping wells operated by his company in which mechanical pumps are employed for lifting the oil to the ground surface, it is necessary for him to have information as to the pressure at the pump inlet or at other levels below the liquid surface of the well; That it is desirable for him also to know the density of the oil in the well and it is desirable for him to determine the production capacity or possi-

Defendant's Exhibit Q—(Continued)

bility of the wells operated by The Texas Company (Calif.); That The Texas Company (Calif.) has employed the Depthograph Company to make tests and measurements on at least thirty-seven (37) wells to determine the pressures, densities and production capacities as stated above.

That he is personally acquainted with the inventor Cranford P. Walker and is familiar with the methods and apparatus employed by Cranford P. Walker on behalf of the Depthograph Company.

That the use of the Walker method of obtaining pressure, density and production capacity has solved the problem which to affiant's knowledge petroleum engineers have long been seeking an answer.

That to affiant's personal knowledge the Walker method as aforesaid has saved great quantities of time and appreciable expense in determining the information referred to herein.

That affiant first learned of the Walker method of obtaining pressure information, density information and production capacity in pumping wells on or about August 1, 1936, and this method was employed on wells of The Texas Company (Calif.) located at Signal Hill and Santa Fe Springs fields in Los Angeles County, and in oil fields in Kern County, California.

(Signed) R. L. KEYES.

Defendant's Exhibit Q—(Continued)

Subscribed and sworn to before me this the 6th day of February, 1939.

SADIE HAWKINS,

Notary Public in and for the County of Los Angeles, State of California.

Mr. commission expires Mar. 26, 1941.

#14

Address Only
The Commissioner of Patents
Washington, D. C.

U. S. Patent Office. Commissioner's Office. Feb. 13, 1939. Copy Mailed.

Department of Commerce
United States Patent Office
Washington

Feb. 13, 1939

Ex parte Cranford P. Walker,
Serial No. 171,170,
Filed October 26, 1937,
Method of Determining Fluid Density,
Fluid Pressure and the Production.
Capacity of Oil Wells.

PETITION TO MAKE SPECIAL

The petition to make this case special has been considered.

If the examiner can make this case special without prejudice to any possible interfering applications, and he should make a rigid search for such,

Defendant's Exhibit Q—(Continued)

he is authorized to do so for the next action. Should the application be rejected again, the case will not be considered special for the subsequent action unless the applicant promptly makes a bona fide effort to place the case in condition for allowance even if it is necessary to have an interview with the examiner to accomplish this purpose.

If the examiner finds any interfering application for the same subject matter, he should consider such application simultaneously with this case and should state in the official letter of such application that he is taking it out of its turn because of a possible interference.

The petition is granted.

JUSTIN W. MACKLIN,
First Assistant Commissioner.

Mr. Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope St.,
Los Angeles, Calif.

Defendant's Exhibit Q—(Continued)

23-17

Div. 36
Cranford P. Walker,
Serial No. 171,170

The examiner will please send the file of this application to ~~Mr. E. T. Newton, Room 3628~~ Mrs. Peterson, Room 3898, indicating hereon when the application will be reached for action.

CONWAY P. COE,
Commissioner.

This application will be acted upon April 3, 1939.

Date Feb. 13, 1939.

M. BUCHLER.
(To be signed by person reporting.)

Defendant's Exhibit Q—(Continued)

Div. 36 Room 7892

260

Buchler:mwc

Address only

"The Commissioner of Patents,

Washington, D. C.,"

and not any official by name

Paper No. 15

All communications respecting this application should give the serial number, date of filing, and name of the applicant

Department of Commerce

United States Patent Office

Washington

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE,

Commissioner of Patents.

Harold W. Mattingly,
924 Pacicif Finance Bldg.,
621 S. Hope Street,
Los Angeles, California.

Applicant: Cranford P. Walker
Ser. No. 171170.
Filed Oct. 26, 1937

For Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells

Responsive to amendment filed January 3, 1939. It was understood that the Applicant intended to

Defendant's Exhibit Q—(Continued)

file a supplemental amendment and the examiner has waited a reasonable time for the filing of such amendment. However, in view of the fact that this application has been made special, it is taken up for examination at once.

In line 1 of page 13, "10" should be 12.

The drawing should show a pressure gage connected to the casing head.

Claims 12 to 17, 23 to 33, 35 to 38, and 39 to 45 are in the case.

Claims 12 to 17, inclusive, are rejected on the ground of misjoinder of invention. In the second Office action, division between claims 12 to 17 and another group of claims was made final after approval of the Examiner of Classification. In response to the second Office action, Applicant did not elect to prosecute claims 12 to 17.

The requirement for election of species in the last Office action has been traversed by applicant on the ground that the claims did not fall within the groups as stated in said action. Said requirement has been submitted to the Examiner of Classification who states:

"Division has been required under Rule 41 between:

I. Claims 24, 25, 35, 36, 44 and

II. Claims 23, 37, 38, 45.

There appear to be no generic claims, the remaining claims in the case, 26-33 and 39-43, being sub-generic, and claims 12-17 being retained under Rule 42.

Defendant's Exhibit Q—(Continued)

The groups cover mutually exclusive species and division is approved, pending the non-allowance of a generic claim."

With the approval of the Examiner of Classification, the requirement for division between (I) claims 24, 25, 35, 36, 44 and (II) 23, 37, 38, 45 is now Made Final.

Upon reconsideration of this application in the light of the last amendment, it is found that the novel method disclosed is that of measuring the density of the standing column of liquid existing between the well casing and tubing string 5. Accordingly claim 28 is allowable.

Claims 26, 30 and 33 are rejected as being non-inventively different from claim 28, all of these claims differing from each other only by verbiage.

Claims 27, 29 and 31 are rejected as being incomplete because the step of measuring the level of the liquid surface after the pressure in the well has been changed, is not included. Apparently the new stable level of liquid must be measured after the pressure has been changed in order that the density may be determined. The claims should include all essential steps.

Claims 30 and 32 are further rejected as incomplete because the steps of measuring the liquid surface levels are not included.

Claims 31 and 32 are further rejected as incomplete because each fails to state that the liquid operated upon lies between the pump tubing and

Defendant's Exhibit Q—(Continued)

the well casing. A perusal of Applicant's specification reveals that the method of measuring density must be performed upon the standing column of liquid between casing 1 and tubing 5. The method would not apparently be operative when performed on the liquid within tubing 5. The claims should therefore state that the levels measured are those of the surface of liquid between casing 1 and tubing 5.

Claims 39 and 40 are rejected as covering only common sense ways of measuring pressure at a point in the liquid in an oil well.

Claim 39 is further rejected as unpatentable over page 194 or the 1931 volume or pages 353 and 354 of the 1932 volume
^ the Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, each of record. Applicant states that the pressure of a point in the liquid in a flowing well varies as the depth below the surface and he further states that the density of the liquid in a flowing well varies as the depth. These facts are immaterial as far as claim 39 is concerned because the steps of this claim merely result in the determination of the pressure at the liquid surface. Therefore, it would not be invention to use the methods of these references to determine the pressure in a pumped well.

Also, Applicant states that page 194 does not apply because this reference states how the pressure at the bottom and the bottom only may be

Defendant's Exhibit Q—(Continued)

determined. The bottom may be the desired one of "and desired level" below the normal surface of the liquid and therefore claim 39 is anticipated.

Claim 40 is further rejected as unpatentable over pages 353, 354, and 359 of the 1932 volume or page 194 of the 1931 volume of the Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, each of record. It would not be invention to use the methods disclosed by these references to determine the pressure in the liquid in a pumped well. If the density of the liquid in a flowing well does vary with the depth, it is not apparent how this fact affects the patentability of the claim. The mere discovery of a scientific truth or fact is not proper subject matter of a patent. The method appears to be the same whether applied to a flowing well or to a pumped well, the main difference being that Applicant has found that the method is more easily applied to a pumped well.

Claims 41 and 43 are objectionable since these claims include many surplus steps. In order to determine only liquid pressure, it is not necessary that the casing pressure and level be altered, etc.

Since claims 41 and 43 merely determine liquid pressure at any desired level, these claims are rejected as unpatentable over the references applied to claims 39 and 40 for the reasons stated above in the rejection of claims 39 and 40.

Claim 43 is further rejected as misleading. How

Defendant's Exhibit Q—(Continued)

may the casing head pressure be noted as stated in the second step if the casing is not closed as inferred from the third step.

Claim 42 is rejected as unpatentable for the reasons stated above in the rejections of claims 39 and 40.

As stated above, the novelty in this case appears to reside in the method of measuring density as stated in allowed claim 28. The method of determining pressures appears to involve only obvious steps of computation or operation of the well and this method does not appear to be patentable.

The description should be amended to state more clearly that the density, pressure, etc. are determined by performing operations in connection with the column of fluid between casing 1 and tubing 5.

A. D. McFADYEN,
Examiner.

Submitted Feb. 24, 1939. Supervisory Examiner.

Defendant's Exhibit Q—(Continued)

Application Div., U. S. Patent Office. Mar. 6, '39.

U. S. Patent Office. *Mar 6 1939* Division 36.

In the United States Patent Office.

Division 36—Room 7892

Cranford P. Walker

Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

Filed October 26, 1937.

Serial No. 171,170

Los Angeles, California

March 3, 1939

Hon. Commissioner of Patents

Washington, D. C.

Sir:

In response to the Office action of February 24, 1939, please amend the above identified application as follows:

Page 1, Line 21, change "50-150" to read—50 to 150 feet—.

Page 5, Line 1, after "be" insert—either—; same line, after "to" cancel "either"; Line 18, before "liquid" insert—standing column of—; Line 20, cancel "the well" and substitute—such column—; Line 22, before the period insert—by the usual pumping apparatus employed therein—; Line 25, cancel "fluid"; same line, after "surface" insert —of the standing column of liquid in the well—; Line 29, cancel "producing"; same line, before the

Defendant's Exhibit Q—(Continued)

period, insert—being produced by a mechanical pump—.

Page 6, cancel from Line 12 through Line 4 on Page 7.

Cancel from Line 23 on Page 7 through Line 2 on Page 8 and substitute the following:

(D1)

—Another object of my invention is to provide a ready method for determining the potential production capacity of a well by determining the liquid pressure at some point below the liquid surface in the well, either at the pump inlet or any other location, under two conditions of production from the well (one of which may be zero production), and by comparing the pressures so determined with the production rates, determining the maximum potential production obtainable from the well.—

Page 9, Line 10, change "the" to read —a—.

Page 11, Line 5, after "surface" insert —of the "standing column" of liquid within the well—; Line 9, after the period, insert

(D2)

—The expression "standing column" as used herein is intended to mean the column of liquid which stands in the well as distinguished from the pumped liquid column which is being lifted to the ground surface by the pump, such standing column being known in the oil industry as the "dead" liquid column and with the usual type of pumping appa-

Defendant's Exhibit Q—(Continued)

ratus this standing column lies in the annular space between the tubing 5 and the casing 1.—; Line 18 before "well" insert

—annular space between the tubing 5 and the—; Line 25, after the comma, insert —as by means of a pressure gauge 13,—.

Page 12, Lines 25 and 29, after "chart" insert —shown in Fig.—.

Page 13, Line 1, change "10" to read —12—; Line 11, change "multiplied by 3" to read —represented at 3a (Fig. 2)—.

Page 14, Line 2, change "fluid" to read —standing column of liquid mixture of oil and gas—; Lines 4 and 11, after "chart" insert —shown in Fig.—; Line 23, change "oil" to read —liquid—.

Page 15, Line 3, change "fluid" to read —liquid—; Line 5, change "oil" to read —liquid mixture of oil and gas—; same line, after "well" insert

(D4)

—(that is, the pressure exerted by this mixture per unit of height of the column of liquid mixture)—; Line 9, change "oil" to read —liquid—.

Page 16, Line 15, change "fluid" to read —liquid—; same line, correct the spelling of "corresponding".

Page 17, Line 3, change "fluid" to read —liquid—; Line 5, after the period, insert

(D5)

—I have discovered that in wells employing mechical pumps for any given production rate by the

Defendant's Exhibit Q—(Continued)

pump, the density of the oil and gas mixture is constant throughout the height of the standing column of liquid in the annular space between the tubing and casing so that the line C once established continues as a straight line, the effect in pressure per unit of height of the column being constant throughout the height of the column.—

Cancel Claims 12 through 27, 30, 32, 33, 35 through 40, and 42 through 45.

Rewrite Claim 28 as follows:

(D6)

2—~~46~~. The method of determining the density of liquid in a well having a casing and a pump suspended therein on tubing and without requiring removal of pump parts, which consists in determining the liquid level in the annular space between the pump tubing and the casing under one condition of pressure, changing the pressure of the gas within the well to move the liquid surface to a new stable level, measuring the new level and dividing the change in pressure on the fluid surface required to achieve the new level by the difference between the two levels.—

Rewrite Claim 29 as follows:

(D6)

3—~~47~~. The method of determining the density of the standing column of liquid in a well having a casing and a pump suspended therein, which consists in measuring the level of the standing column of liquid in the well while the pump therein is op-

Defendant's Exhibit Q—(Continued)

erated at a given rate of production and under a known condition of gas pressure on the surface of the liquid column, changing the gas pressure on the liquid column, continuing the operation of the pump at the same production rate until the level of the standing column becomes stable at a new location, measuring the new level and comparing the difference in the pressures exerted on the liquid surface at the two levels with the difference in hight of the two levels.—

Rewrite Claim 31 as follows:

(D6)

~~4~~—~~48~~. The method of determing the density of the standing column of liquid in a well having a casing and a pump suspended therein, which consists in measuring the stable level of the surface of the standing column of liquid under one condition of pressure of gas released by the well, measuring the pressure on said liquid surface under said one condition of gas pressure, regulating the flow of gas from the well to increase the pressure of said gas to a different value to depress the surface of said standing column to a new stable level, measuring the new level, measuring the pressure on the liquid surface at the new level, and comparing the difference in the pressures exerted upon the liquid surface under the two conditions of gas pressure with the difference in height of the levels of the liquid surface under the two pressure conditions.—

Defendant's Exhibit Q—(Continued)

Add the following claim:

(D7)

5—~~49~~. The method of determining the density of the standing column of liquid in a well, which comprises measuring the stable level of the liquid column under one condition of gas pressure, changing the pressure of gas within the well to move the surface of the liquid column to a new stable level, measuring the new stable level and dividing the change in pressure on the liquid surface required to achieve the new level by the difference in height between the two levels.—

Claim 41, cancel from "liquid" in Line 1 through "liquid" in Line 2, and substitute the following: —density of the standing column of liquid—; Line 5, cancel "the pump" and substitute —pump parts—; Line 11, after "pump" insert —at the same rate of production—; Line 14, change "noting" to read —measuring—; Line 19, cancel "gas".

Add the following claims:

(D8)

6—~~50~~. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted in the standing column of liquid in the well at any desired level below the normal surface of said column and without requiring the removal of any of the pump parts, which comprises measuring the actual stable level of the liquid column under one known condition of gas pressure in the casing, determining the pressure on the liquid surface at that level, changing the pressure of gas in the well to move the surface of said

Defendant's Exhibit Q—(Continued)

column to a new actual stable level, measuring the new level of the liquid surface, determining the pressure on the liquid surface at the new level, determining the density of the liquid by dividing the change in pressure on the liquid surface required to achieve the new level by the difference in height of the two levels and computing the unknown pressure at the desired level by adding to the pressure on the liquid surface at either of the levels the effect in pressure of the column of liquid of the density so determined between the selected actual level and the desired level.

7—~~51~~. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted by the standing column of liquid at any desired level below the normal surface of said column while the pump is operating to remove liquid from the well, which comprises measuring the actual stable level of the liquid under one known condition of gas pressure in the well by sonic sounding method, determining the pressure on the liquid surface at that level, changing the pressure of the gas in the well to move the surface of the column to a new actual level, continuing to operate the pump at the same production rate as for the first condition of gas pressure in the well until the liquid level again becomes stable, measuring the new stable level and determining the pressure upon the liquid surface at this new level, determining the pressure exerted per unit of height of the liquid column by

Defendant's Exhibit Q—(Continued)

dividing the change in gas pressure on the liquid surface required to effect the change in the liquid level by the difference in height of the two levels, and computing the unknown pressure at the desired level by adding to the gas pressure upon the liquid surface at either of the actual levels the effect in pressure of the liquid column between the selected actual level and the desired level.

8—52. The method of determining the potential production capacity of a well having a casing and a pump suspended therein, which comprises measuring the stable level of the surface of the standing column of liquid in the well at one known rate of production and under one known condition of gas pressure in the well, determining the pressure on the surface of the liquid column at that level, changing the gas pressure in the well to move the surface of the liquid column to a new stable level, measuring the level of the liquid surface under the new gas pressure condition and determining the pressure on the liquid surface at the new level, dividing the change in pressure on the liquid surface by the difference in height between the two levels to thereby determine the density of the liquid in the column at that rate of production, determining the pressure at some predetermined desired point below the normal liquid surface for that rate of production by adding to the pressure on the liquid surface for either of the measured levels the effect in pressure of the column of liquid between that level and the predetermined desired point, then changing the rate of

Defendant's Exhibit Q—(Continued)

production by the pump and repeating the liquid level change and gas pressure determinations to determine the density of the liquid in the column and the pressure of the liquid at the said predetermined desired point for the new rate of production and then dividing the difference in the two production rates by the difference in the corresponding liquid pressures at the desired point and using the ratio thus found to determine the maximum rate at which the well is capable of being produced.—

REMARKS

In making the foregoing amendments, the applicant sincerely appreciated the action entered by the Examiner on February 24, 1939 and wishes to express apologies for being unable to have completed this amendment prior to the entry of that Office action. However, it is believed that the entry of the Office action of February 24, 1939 clarifies the situation with regard to this case so that this amendment may place this case in condition for an immediate allowance.

In making the foregoing amendments, the applicant has attempted to conform exactly with the discussion had with the Examiner in charge of this application, the Primary Examiner of this division and the Supervisory Examiner at the oral interviews had during the week of February 6, 1939 and it is believed that the Examiner will find that each of the claims now presented in this application pre-

Defendant's Exhibit Q—(Continued)

sents the subject matter which was discussed and agreed upon as allowable in this case.

However, for the assistance of the Examiner in considering the claims, all of the claims have been rewritten in this amendment in order to gather them together in one place, new Claim 46 representing old Claim 28 which was indicated as allowable by the Supervisory Examiner. The only alteration which has been made in Claim 46 over the exact wording of Claim 28 has been in leaving out the word "and", first occurrence, from Line 2 of Claim 28, this word being entirely unnecessary and merely acting to confuse the claim.

New Claim 47 is old Claim 29 rewritten in accordance with the changes suggested at the oral interviews for the purpose of making this claim more complete.

At this point it should be noted that upon the consideration of this application at the oral interviews it was pointed out to the Examiner that whereas the Examiner had apparently misunderstood the action which takes place in the oil well under the applicant's method of determining density and had considered that increasing pressure upon the liquid surface would displace the liquid by driving it back into the formation, the actual conditions which do prevail in an oil well which is being pumped by a mechanical pump are that the standing column of liquid (that is, the column of liquid in the annular space between the pump tubing and the casing) is substantially the same density throughout its height,

Defendant's Exhibit Q—(Continued)

this condition existing because of the fact that the standing column of liquid is a mixture of gas and oil in which the gas bubbles are smaller in the lower portion of the column than close to the surface of the column while the rate at which the bubbles are moving through the column increases as these bubbles approach the surface. Hence, though the bubbles close to the surface are larger, they are traveling at such a rapid rate that their effect as regards the density of the column is the same at or near the surface of the column as they are further down in the column.

The applicant takes advantage of this constant density (or, as may be expressed in another way, the effect in pressure per unit of height of the colum, is constant throughout the standing column) by first measuring some one stable level of this standing column and then changing the location of the surface of the column, either by increasing the pressure of gas on the liquid surface or decreasing the pressure on the liquid surface, thus providing a measure of the density of the liquid in the column without changing the rate of flow of the oil and gas mixture from the formation. This method of determining that density of the dead liquid or standing column of liquid is not disclosed in any of the references of record, the only density measurements referred to in the references being directed to the use of pressure bombs which are inserted in the well after the removal of the pump

Defendant's Exhibit Q—(Continued)

and tubing from the well and the applicant has therefore provided a new and novel means of determining this density.

Upon the presentation of this explanation to the Examiner, the Primary and the Supervisor, it was agreed that this is a new and novel method and that claims defining this along the lines of original Claim 28 would be considered as allowable over the references of record.

Upon reviewing Claims 27, 29, 30, 31, 32 and 33 with the Examiner, it was found that a number of essential steps had not been definitely recited and it is for this reason that the applicant has carefully reviewed these claims and has substituted for them Claims 47, 48 and 49.

Claim 47 expresses the same subject matter as original Claim 28 (now Claim 46) but with the limitation that the measurements are made while the pump is operating at a given rate of production, and including the additional step that after the change in the level of the standing column has been achieved the pump is again operated at the same rate of production until the column becomes stable at the new level.

In connection with the consideration of the new Claims 47 through 52, the Examiner's attention is called to the fact that each of these claims describes the particular kind of fluid column upon which the measurements are to be made as the "standing column of liquid" in the well, the specification having been amended to accurately and definitely describe

Defendant's Exhibit Q—(Continued)

this standing column of liquid as that column of liquid which exists in wells that are being pumped and which column of liquid lies in the annular space between the casing and the tubing as distinguished from the fluid which has passed through the pump and which may now be terms "pumped fluid". It is, of course, understood and is explained in the specification that with present day types of pumps the standing column lies in the annular space between the tubing and the casing but might equally as well occupy some other space in the well where conditions were reversed and the annular space was used for the passage of the pumped liquid. In either event, however, the expression "standing column of liquid" as defined in the specification would be an accurate expression of exactly that portion of the liquid in the well upon which applicant's method is practiced.

New Claim 48, which represents old Claim 31 rewritten, defines the same subject matter as Claim 28 (now Claim 46) with the limitation that the change in the location of the liquid level is brought about by the gas which is released from the well and includes the step of "regulating the flow of gas from the well to increase the pressure of said gas to a different value to depress the surface of said standing column to a new stable level. It is believed that this claim clearly and patentably distinguishes from both Claims 26 and 27.

New Claim 49 is directed to the same subject mat-

Defendant's Exhibit Q—(Continued)

ter as old Claim 28 but expresses the invention in somewhat different language, this claim including each of the steps set forth in Claim 28 and this claim was indicated by the Examiner to be an allowable expression of the invention.

Claim 41 has been amended, as indicated in the Office action of February 24, 1939, to define the invention in terms of "density" instead of in terms of pressure, this claim having originally been inaccurately worded. It is believed that the amendments in this claim accurately and completely express each of the necessary steps of the method which was found to be allowable in Claim 28.

Claims 50 and 51 are directed to the applicant's method of obtaining the pressure at various or any point below the surface of the standing column of liquid in the well, which includes the steps of first determining the density of the column and then employing that information to compute the pressure which will exist at the desired or unknown level. Claim 50 expresses this subject matter in terms of density measurement while Claim 51 expresses this subject matter in terms of "pressure exerted per unit of height of the liquid column".

Claim 52 is directed to the employment of the applicant's method of obtaining density measurements in the liquid column for the purpose of computing the maximum production capacity of the well.

The subject matter of Claims 50, 51 and 52 was considered by the Examiner at the oral interviews and was indicated as clearly allowable over the ref-

Defendant's Exhibit Q—(Continued)

erences in that they employ the new and novel method of obtaining the density measurements by which the density measurements or computation of pressure and production capacity could be made.

In accordance with the suggestion made by the Examiner, permission is requested to amend the drawings in this application as indicated in red ink on the accompanying print.

It is believed that the foregoing amendment, limiting the claims of this application to the subject matter which was discussed with the Examiner and which was as pointed out above clearly patentable over any of the references of record, places this case in condition for immediate allowance, which action is respectfully requested.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant

HWM:MM

Defendant's Exhibit Q—(Continued)

#17

U. S. Patent Office Mar 6 1939 Division 36
Application Div. Mar 6 '39 U. S. Patent Office.

In the United States Patent Office
Division 36 — Room 7892
Account

Cranford P. Walker
Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells

Filed October 26, 1937
Serial No. 171,170

Los Angeles, California
March 3, 1939

Hon. Commissioner of Patents
Washington, D. C.

Sir:

Attention: Office Draftsman

Please instruct the Office Draftsman to make the changes indicated in red ink in the accompanying print.

Please charge the cost of making this change to my miscellaneous fees account.

Respectfully submitted
HAROLD W. MATTINGLY
Attorney for Applicant

Approved, M. B. Div. 36, March 7, 1939.
Received in Div. C Mar 8 1939.
Correction ordered Mar 8 1939 Account 5W.
Div. C Corrected Mar 8 1939.

HWM:MM

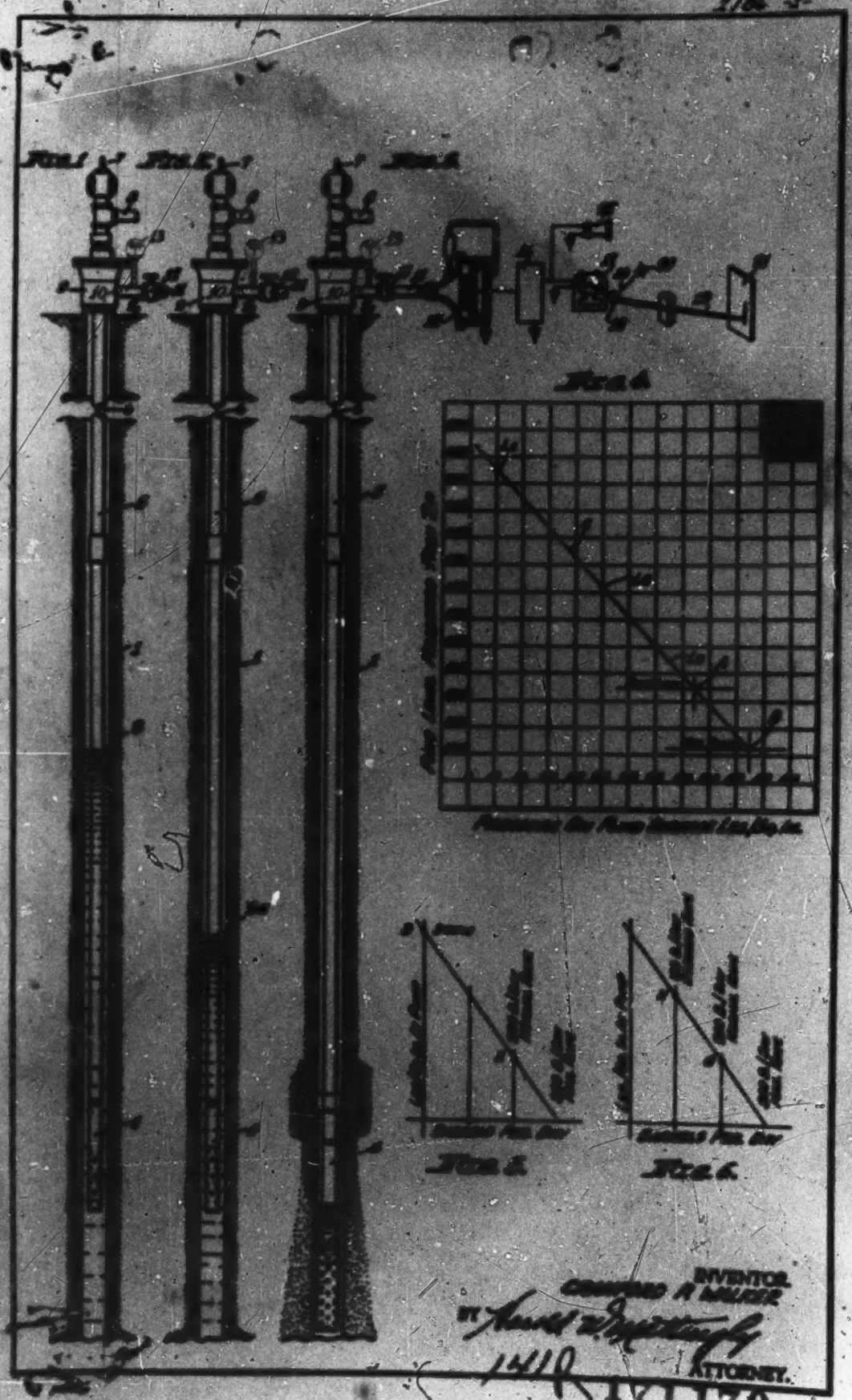


Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
INVENTOR
CRAWFORD A. WALKER
BY
ATTORNEY.

1410

171170

Defendant's Exhibit Q—(Continued)

Div. 36 Room 7892

Buchler:mwc

Department of Commerce
United States Patent Office
Washington

Paper No. 18

All communication respecting this application should give the serial number, date of filing, and name of the applicant

Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name

Mailed Mar 14 1939.

Please find below a communication from the EXAMINER in charge of this application

CONWAY P. COE
Commissioner of Patents.

Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope Street,
Los Angeles, California.

Applicant Cranford P. Walker
Ser. No. 171170
Filed Oct. 26, 1937
For Method of Determining Mining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells

In accordance with the provisions of Order No.

Defendant's Exhibit Q—(Continued)

2308, dated March 12, 1917, which reads in part as follows:

* * * * * * * * *

Obvious informalities in the application may be corrected by the examiner, but said correction must be in the form of an amendment, approved by the Principal Examiner in writing, placed in the file, and made a part of the record. The changes specified in the amendment will be entered by the clerk in the regular way.

* * * * * * * * *

the changes, hereinafter specified, are made by the examiner in the application above identified.

Should these changes not be satisfactory to the applicant, appropriate amendment may be proposed under the provisions of Rule 78, provided the specification has not been printed.

The application has been amended as follows:

In line 19 of claim 51, by the difference in height of the two levels has been inserted after "level".

A. D. McFADYEN
Examiner.

Defendant's Exhibit Q—(Continued)

[Printed in Margin]: In Remitting the Final Fee Give the Serial Number at the Head of This Notice.

[Printed in Margin]: Uncertified Checks Will Not Be Accepted.

181

Div. 36-Rm 7892-mwc

Serial No. 171170

Mailed Mar 15 1939.

Department of Commerce
United States Patent Office
Washington
Address Only
The Commissioner of Patents
Washington, D. C.

March fifteenth, 1939

Cranford P. Walker,

Your Application for a patent for an Improvement in Method of Determining Fluid Density Fluid Pressure and the Production Capacity of Oil Wells filed Oct. 26, 1937 has been examined and Allowed with 8 claims.

The final fee, Thirty Dollars, With $1 Additional for Each Claim Allowed in Excess of 20, must be paid not later than Six Months from the date of this present notice of allowance. If the final fee be not paid within that period, the patent will be withheld, but the application may be renewed within one year after the date of the original notice with a renewal fee of $30 and $1 additional for each claim in excess of 20.

Defendant's Exhibit Q—(Continued)

The office delivers patents upon the day of their date, on which date their term begins to run. The preparation of the patent for final signing and sealing will require about four weeks, and such work will not be begun until after payment of the necessary final fee.

When the final fee is paid, there should also be sent, Distinctly and Plainly Written, the name of the Inventor, Title of the Invention, and Serial Number as Above Given, Date of Allowance (which is the date of this circular), Date of Filing, and, if assigned, the Names of the Assignees.

If it is desired to have the patent issue to an Assignee or Assignees, an assignment containing a Request to that effect, together with the Fee for recording the same, must be filed in this office on or before the date of payment of the final fee.

After issue of the patent, uncertified copies of the drawings and specifications may be purchased at the price of Ten Cents Each. The money should accompany the order. Postage stamps will not be received.

The final fee will Not be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

Defendant's Exhibit Q—(Continued)

Notice.—When the Number of Claims Allowed Is in Excess of 20, No Sum Less Than $30 Plus $1 Additional for Each Claim in Excess of Twenty Can Be Accepted as the Final Fee.

Respectfully,

CONWAY P. COE

Commissioner of Patents.

Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope Street,
Los Angeles, California.

Walter P. Huntley MAdison 1137

Harold W. Mattingly
Attorney at Law
Patent and Trademark Causes
621 South Hope Street
Los Angeles, California

Apr-3-39 197020 D—Check—30.00
Mail Division Apr 3 1930 U. S. Patent Office.

March 30, 1939

Commissioner of Patents
Washington, D. C.

Sir:

Enclosed herewith please find my check No. 1133 in the sum of $30.00 to cover the final Government fee in the matter of the application for United States Letters Patent for Method of Determining

Defendant's Exhibit Q—(Continued)

Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

Name of Inventor: Cranford P. Walker

Serial No. 171,170

Filed October 26, 1937

Allowed March 15, 1939, with 8 claims.

Respectfully,

HAROLD W. MATTINGLY

MM

#19

Div. 36—Room 7892

U. S. Patent Office Apr 18 1939 Issue Division.

Rule 78 Apr 18 1939 Orders No. 2698, 2801, 3311.

In the United States Patent Office

In re Application of

Cranford P. Walker

Serial No. 171,170

Filed October 26, 1937

Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells

Washington, D. C., April 18, 1939.

Hon. Commissioner of Patents,

Washington, D. C.

Sir:

Amendment Under Rule 78

Please amend the above-entitled application as follows:

Cancel Fig. 3.

Defendant's Exhibit Q—(Continued)

In the specification, page 8, omit description of Fig. 3 and change Figs. 4, 5 and 6 to read —Figs. 3, 4 and 5—.

Page 12, change "Fig. 4" to read —Fig. 3— in lines 15, 25 and 29.

Page 13, line 7, after "to" insert —three times the length of—.

Page 14, lines 4 and 11, change "Fig. 4" to read —Fig. 3—.

Page 16, lines 10 and 26, change "Fig. 4" to read —Fig. 3—.

Page 17, line 26, change "potential" to read —rates of—.

Page 19, lines 4, 9, 22, 24 and 27, change "Fig. 5" to read —Fig. 4—.

Page 20, line 21, change "Fig. 6" to read —Fig. 5—.

Delete from line 15, page 21, through line 10, page 24.

Page 24, line 27, cancel "of the pump".

REMARKS

This amendment is requested to delete all reference to Figure 3 including the description thereof in the specification.

It will be noted that division was required in this case between the subject matter of Figure 3 and the remaining matter and a divisional application is being filed before issue of this application to cover said Figure 3.

Defendant's Exhibit Q—(Continued)

Under the common practice, the Office should have required cancellation of all reference to Figure 3 and the applicant is now seeking to do what should have been done in accordance with the accepted practice.

In view of the fact that said divisional application may remain pending for an appreciable period of time, it would seriously affect applicant's commercial efforts and disclose to the public, without claims thereto, the modification shown in said Figure 3.

Respectfully submitted,

RAYMOND JONES,

Associate Attorney.

Defendant's Exhibit Q—(Continued)

Div. 36 Room 7892

1-b

Buchler:mwc

Paper No. 20

Address only

"The Commissioner of Patents
Washington, D. C.",
and not any official by name

All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Mailed Apr 18 1939

Department of Commerce
United States Patent Office
Washington

April 18, 1939

Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope Street,
Los Angeles, California.

Applicant: Cranford P. Walker
Ser. No. 171170
Filed Oct. 26, 1937
For Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells

The entry of the amendment proposed under Rule

Defendant's Exhibit Q—(Continued)

78 has been disapproved. A copy of the examiner's adverse report appears below.

CONWAY P. COE,
Commissioner of Patents.

The specification has been printed and the drawing has been photolithographed so that it is too late to eliminate a figure from the disclosure.

E. D. BROMLEY,
Actg. Examiner.

Approved Apr 18 1939.

HENRY VAN ARSDALE,
Asst. Commissioner of Patents.

Defendant's Exhibit Q—(Continued)

#21

Application Div. Apr 20 '39. U. S. Patent Office.

In the United States Patent Office
Division 36—Room 7892

Cranford P. Walker,
Method of Determining Fluid
Density, Fluid Pressure and
the Production Capacity of
Oil Wells,
Serial No. 171,170
Filed October 26, 1937

U. S. Patent Office Apr 20 1939 Issue Division

Los Angeles, California
April 18, 1939

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

I hereby abandon the above entitled application.

Respectfully submitted,
CRANFORD P. WALKER,
Inventor.

[Longhand Notation] Any assignment? No assigt received including Apr. 18, 1939. Spielman.

[Stamped]: Abandoned 4/20/39m 4/20/39L.

Defendant's Exhibit Q—(Continued)

ABS
#22

April 21, 1939

Mr. Cranford P. Walker,
Care Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope St.,
Los Angeles, California.

My dear Mr. Walker:—

I have your letter of Abandonment in connection with your application filed October 26, 1937, for Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells, Serial Number 171,170, allowed on March 15, 1939.

The application has been marked Abandoned in accordance with your request.

Sincerely yours,
J. A. BREARLEY,
J. A. BREARLEY,
Chief Clerk.
L (Div B)

171170—22

Docket Division Aug 10 1939 U. S. Patent Office
Washington, D. C.
Aug. 10, 1939

PETITION FOR ACCESS

Hon. Commissioner of Patents
Washington, D. C.

Access to the application of C. P. Walker, Serial

Defendant's Exhibit Q—(Continued)

No. 171,170, is requested for the purpose of making copies of certain papers in the file.

Application Serial No. 171,170 is the parent case of which the C. P. Walker patent No. 2,161,733, is a continuation.

Respectfully,

MARIE A. AHERN.

O. K. H. S. M. Aug. 12, '39

171170—23.

Docket Division Oct 15 1941 U. S. Patent Office

Law Offices

Earle D. Crammond

Patent and Trade Mark Causes

Earle Building

Washington, D. C.

District 9899

October 13, 1941.

Hon. Commissioner of Patents,

Washington, D. C.

Sir:

Permission is hereby requested for access to the file of the application of Cranford P. Walker, Serial No. 171,170, filed Oct. 26, 1937. This application is referred to in patent Reissue 21,383, in the second paragraph of page 1. Reissue 21,383 is involved in Civil Action 1655-H, Southern District of California. In order to properly prepare the defenses in the aforesaid law suit, access to the

Defendant's Exhibit Q—(Continued)

above noted application must be had, for the purpose of making certified copies.

Very respectfully,

E. D. CRAMMOND.

EDC:I

O. K. 10/15/41.

A. F. ROHRMAN.

421

1937

CONTENTS

1. Application.....papers.
2. Print Oct-30-37
3. Rejection (Division) Feb 5 1938
4. Amdt A Apr-25-38
5. Reg. Div. Approved in Part. June-16-38
6. Asso Pr Atty Apr-28-38
7. Final Action (Division) Jun 20 1938
8. Letter July-9-38
9. Amdt B Oct-5-38
10. Rejection Nov 1-1938
11. Amdt C Jan-3-39
12. Approval Reg. Div. Feb-8-39
13. Petition to Make Special Feb-11-39
14. Petition Granted Feb-13-39
15. Rejection Feb 24 1939
16. Amdt D Mar-6-39
17. Letter (draft) Mar-6-39

Defendant's Exhibit Q—(Continued)

18. Ex. Amdt E Mar-14-39
19. Amdt (Rule 78) Apr 18-39
20. Adverse Notice Sent Apr 18-39
21. Letter April-20-39
22. Petition for access Aug 10, 1939
23. Petition for Access Oct 15, 1941

[Endorsed]: Filed Nov. 9, 1942.

DEFENDANT'S EXHIBIT R

390

Department of Commerce
United States Patent Office

To all persons to whom these presents shall come, Greeting:

This Is To Certify that the annexed is a true copy from the records of this office of File Wrapper and Contents, in the matter of the

Letters Patent of
Cranford P. Walker,

Number 2,161,733, Granted June 6, 1939.

for

Improvement in Methods of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells.

In Testimony Whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this eighth day of May, in the year of our Lord one thousand nine

Defendant's Exhibit R—(Continued)

hundred and forty-two and of the Independence of the United States of America the one hundred and sixty-sixth.

Attest:

[Seal]

D. E. WILSON,
Chief of Division.

CONWAY P. COE,
Commissioner of Patents.

Defendant's Exhibit R—(Continued)
Mail Division Apr 19 1939 U. S. Patent Office
1/86
Apr-19-39 211447 D —Check—
U. S. Patent Office Apr 26 1939 Division 36

PETITION

To the Commissioner of Patents:

Your petitioner, Cranford P. Walker, a citizen of the United States, residing at San Marino, in the County of Los Angeles, and the State of California, whose post office address is 2824 Carlaris Road, San Marino, California, prays that Letters Patent may be granted to him for the Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells set forth in the annexed specification, and he hereby appoints

Harold W. Mattingly
720 Pacific Finance Building
621 South Hope Street
Los Angeles, California
(Registry No. 12,385)

his attorney, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.

(Sign here first name in full)

CRANFORD P. WALKER.

Defendant's Exhibit R—(Continued)

SPECIFICATION

To All Whom It May Concern:

Be It Known, That I, Cranford P. Walker, a citizen of the United States, residing at San Marino, in the County of Los Angeles, and State of California, have invented certain new and useful improvements in Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells of which the following is a specification:

My invention elates to methods of determining the fluid density fluid pressure and potential production capacity of oil wells and has particular reference to methods of determining the most desirable character of pumping equipment and manner of operating the same to permit an efficient production, of oil from a given well.

This application is a continuation of my copending application Serial No. 171,170, filed October 26, 1937.

It is the common practice in oil well production activity to permit an oil well to produce as a flowing well, that is, to permit the oil to flow out at the ground surface due to the pressure in the oil formations, until the production rate reaches a considerably low value or ceases, after which gas lifting is usually attempted and continued until the production rate with gas lifting reaches a relatively low value or the production entirely ceases. At this time, and in some instances prior to any attempt to gas lift the oil, mechanical pumping devices are usually installed to lift the oil by mechanical means to the surface, these pumps usually comprising a pump

Defendant's Exhibit R—(Continued)

barrel located at a considerable depth in the well, usually 50 to 150 feet below the surface of the liquid in the well while it is producing, plungers or other reciprocating devices being employed in the barrel and operated from the ground surface by means of sucker rods.

Usually the selection of the size and character of the pumping equipment is determined by the production of the well during its flowing or gas lifting life by estimating from this production the type or character of pump which appears to be most suitable. In many fields, however, the type, size and character of the pump installed is usually one determined as "standard" for that particular type of well in the particular field. In other words, it is one having the same dimensions as pumps in other wells producing from the same horizon. Frequently, such well receives no further attention until the field as a whole has declined to a point where it becomes necessary to increase the production from the wells, as for example, by the encroachment of water, necessitating the lifting of greater quantities of fluid in order to obtain the desired amount of oil. When this condition occurs, it is customary to increase the capacity of the pumping equipment.

Also, the production from a given well may be believed to be less than the character of the well and the character of the pumping equipment employed should indicate, as for example, the pump may be operating at a relatively low volumetric efficiency.

In order to determine whether or not any change in the size, character, operating characteristics or

Defendant's Exhibit R—(Continued)

location of the pumping apparatus should be made, it is desirable that the location of the liquid surface, the character of the liquid in the well, its density and the fluid pressure at any given point below the surface of the liquid and the maximum potential production capacity of the well should be determined.

For example, if the pumps in a particular field are operating at good volumetric efficiency, much can be determined from the quantity of oil produced and the volumetric displacement per stroke of the pump, and if the pumps are operating at their maximum capacity, the fact that the fluid level is at a considerable distance above the pump inlet may indicate that the operator is justified in making a change in the size or character of the pumping equipment. Again, if the volumetric efficiency of the pump is found to be low, as for example, when the pump appears to be taking in a comparatively large quantity of gas upon each stroke of the pump, the operator should know whether or not the inlet of the pump is located at a point too near the liquid surface so that he may determine how far below the liquid surface he should lower the pump in order to allow it to receive liquid for the full stroke.

Frequently in wells where the quantity of gas produced by the well is relatively small, an increased production of the pump may be obtained by raising the pump to a point nearer the liquid surface so that a better separation of the gas takes place prior to the entry of the liquid into the pump, while if the well

Defendant's Exhibit R—(Continued)

is making a large quantity of gas, it may be better to lower the pump to a point below where the gas is separated from the liquid so that upon each stroke of the pump, dense fluid will be picked up. However, in many instances, it is dangerous to lower the pump too close to the bottom as sand is likely to be pumped into and foul the pump.

In wells where the fluid level is so low that the pump is not completely submerged and hence does not receive a full cylinder or barrel of fluid upon each stroke, a pounding at the pump is created which may be heard or determined at the ground surface. This same character of pounding, however, may be produced by the pump even though the liquid surface is at a considerable distance above the pump inlet, occasioned by the inflow into the pump of large quantities of free gas. Hence, simple tests to determine the fluid level relative to the pump inlet will not produce the desired information to the operator as to the desirable character or location of the pumping mechanism.

If, however, the fluid pressure at different levels below the surface of the fluid is determined, this information may be employed to determine the most desirable location of the pump and whether or not a change should be made in the size, operating characteristics or character of the pumping equipment employed in a given well to produce an increased or maximum production from the well.

The determination of the fluid pressure at different points below the surface of the well may be deter-

Defendant's Exhibit R—(Continued)

mined by instruments known as pressure recorders, which must be either attached to the pump or lowered into the well to the desired level, or must be lowered into the well on wires, cables or other supporting devices and left at the desired levels for a predetermined length of time necessary to permit the recorders to make a chart or record of the pressures encountered. All of these methods, however, require the stopping of the pumps and the stopping of production while the test is being made and further require the removal of the pumps and sucker rods and sometimes the tubing and other apparatus from the well in order to insert the pressure recorders or pressure measuring devices, which entails considerable labor and time and holds up the production of the well for a considerable period of time.

It is therefore an object of my invention to provide methods for determining the fluid pressure at any given point below the surface of the standing column of liquid in the well, determining the density of the liquid in such column and the production index of the well without interrupting or interfering with the production of the well by the usual pumping apparatus employed therein.

Another object of my invention is to provide a ready means for determining the fluid pressure at any level below the surface of the standing column of liquid in the well and for determining the density of the liquid in any particular well without necessitating the removal or replacement of any of the usual pumping apparatus, flow tubes, sucker rods

Defendant's Exhibit R—(Continued)

or other mechanism found in a well being produced by a mechanical pump.

Another object of my invention is to provide information to aid in the determining of the proper location of a pump in an oil well to achieve the maximum volumetric efficiency of the pump in handling the particular character of fluid found in the particular well.

Another object of my invention is to provide a ready method for determining the potential production capacity of an oil well with a minimum of expense, delay or interruption of the production activities of the well.

Another object of my invention is to provide a method of determining the density of the fluid in a well by measuring the amount of recession of the level of the liquid surface under two conditions of pressure upon the liquid surface and computing from the facts thus obtained the density of the fluid in the well. Fluid densities in producing wells range all the way from less than .04 pounds per square inch to over .4 pounds per square inch per 100 feet of fluid in the well. Therefore, a simple fluid level determination without a density or pressure determination gives very little information.

Another object of my invention is to provide a ready method for determining the potential production capacity of a well by measuring the pressure at the pump inlet under two conditions of operation of the pump and computing therefrom the

Defendant's Exhibit R—(Continued)

maximum potential production obtainable from the well.

Another object of my invention is to provide a ready method for determining the potential production capacity of a well by determining the liquid pressure at some point below the liquid surface in the well, either at the pump inlet or any other location, under two conditions of production from the well (one of which may be zero production), and by comparing the pressures so determined with the production rates, determining the maximum potential production obtainable from the well.

Other objects of my invention will be apparent from a study of the following specification read in connection with the accompanying drawing, wherein

Fig. 1 is a diagrammatic, cross-sectional view of a typical oil well, illustrating the level of the liquid surface as being located a considerable distance above the inlet of the pumping apparatus employed.

Fig. 2 is a view similar to Fig. 1 but illustrating the effect on the liquid surface of gas pressure allowed to build up in the casing.

Fig. 3 is a diagrammatic view illustrating a chart or graph which may be employed in the practice of my method for the computation of fluid density and pressures at different locations or levels within the well;

Fig. 4 is a diagrammatic view illustrating a chart or graph which may be employed to compute the

Defendant's Exhibit R—(Continued)

maximum potential capacity of a well from a comparison of the pressure at the pump while it is idle with the pressure at the pump while it is operating normally; and

Fig. 5 is a view similar to Fig. 4 illustrating the manner in which a more accurate computation of the potential capacity of a well may be obtained by comparing the pressure at the pump under two production rates of the pumping apparatus.

Referring to the drawings, I have illustrated in Fig. 1 a typical oil well which includes a casing 1 extending down through the well bore from the ground surface 2 into the oil producing sands, the oil flowing from the sands or oil formation into the casing and rising in the casing to some level indicated at 3. Pumping apparatus employed to remove the oil from the well usually includes a suitable pump 4 located upon tubing string 5, constituting the flow tubing through which the oil is raised to the ground surface, the pump 4 including usually some reciprocating mechanism operated by reciprocal movements of a string of sucker rods 6 extending down through the tubing 5 and connected to reciprocating power apparatus at the ground surface, as indicated at 7. The flow tubing 5 is provided with an outlet 8 communicating with a suitable oil line through which the oil pumped from the well is conveyed to any desired location.

The casing 1 is closed at its upper end as indicated at 9, an outlet 10 being provided com-

Defendant's Exhibit R—(Continued)

municating with the casing 1 to permit gas escaping from the oil to pass into a suitable gas line 11, a control valve 12 being usually provided to control the flow of gas into the gas line.

By properly selecting the size, the stroke and the speed of the pump 4, the pump may be made to remove the oil from the well at approximately the same rate at which the oil flows into the well from the surrounding formation, and if so selected, the well will be operated at its maximum capacity. However, oil coming from the formation contains relatively large quantities of gas which, due to the pressure of the oil, cannot readily escape but which when the oil enters the pump tends to expand in the pump, reducing the volumetric efficiency of the pump. If now the pump is so located relative to the liquid surface that the greater portion of the gas within the well has been permitted to escape prior to the entry of the oil into the pump, it follows that upon each strike of the pump, the pump will be operated upon relatively dense fluid and will hence operate at relatively high volumetric efficiency.

I have discovered that a ready means for determining not only the pressure existing at the pump without requiring the removal of the pump or any of its apparatus but also I have discovered a ready method for determining the density of the fluid at the pump entrance, the information so obtained being used in the location of the pump at the most

Defendant's Exhibit R—(Continued)

desirable level to obtain the maximum volumetric efficiency of the pump.

To obtain the information required, I measure or determine the stable location of the liquid surface of the "standing column" of liquid within the well when the pump is operating at its normal production capacity and with the pressure of gas within the casing at the usual or normal value maintained during the usual or normal pumping operations at the well. The expression "standing column" as used herein is intended to mean the column of liquid which stands in the well as distinguished from the pumped liquid column which is being lifted to the ground surface by the pump, such standing column being known in the oil industry as the "dead" liquid column and with the usual type of pumping apparatus this standing column lies in the annular space between the tubing 5 and the casing 1. This location of the fluid level may be readily accomplished by employing the methods and apparatus disclosed in United States Letters Patent No. 2,047,974, issued to Harold T. Wyatt and Paul E. Lehr, July 21, 1936, and in my copending applications Serial No. 162,699, filed September 7, 1937, and Serial No. 164,534, filed September 18, 1937. While the methods and apparatus are completely disclosed in the said patent and applications, the method may be stated briefly as including the introduction into the annular space between the tubing 5 and the well casing of a sudden change in pressure in the well casing and meas-

Defendant's Exhibit R—(Continued)

uring the length of time elapsing between the production of this pressure impulse and the return to the ground surface of the echo thereof from the surface of the fluid. By noting the distance from the ground surface of the fluid level under these conditions and by noting the pressure of gas at the casing head, as by means of a pressure gauge 13, the pressure on the liquid surface may be computed as follows: to the casing head pressure is added the effect of pressure on the liquid surface exerted by the weight of the column of gas between the liquid surface and the casing head. A gravity test may be made of the gas at the casing head which will determine the pressure exerted by each foot or hundred feet of height of the gas column. This information may be computed by the following formula which is by Dice:

$$\text{Log}_{10}\text{Pb} = \frac{\text{SD}}{1.22.82\text{T}} + \text{Log}_{10}\text{Pt}$$

Where

Pb. = Lbs/sq. in. absolute at bottom of gas column.

Pt. = Lbs/sq. in absolute at top of gas column.

S = Specific gravity of the gas (air is considered 1).

D = Dept from casing head to liquid surface.

T = Mean temp. of the gas column in degrees F absolute.

This information may then be plotted upon a graph or chart illustrated in Fig. 3 in which the

Defendant's Exhibit R—(Continued)

conditions existing in the particular well under measurement are assumed to be such that with a pressure of 36 pounds per square inch at the casing head, the liquid surface is found to lie at 3100 feet below the casing head. The specific gravity of the gas in this instance may be found to be such that the effect will be to produce 4 pounds per square inch pressure on the liquid surface. Thus, the addition of 36 pounds and 4 pounds produces a total pressure on the liquid surface of 40 pounds per square inch. By arranging the chart shown in Fig. 3 with the ordinates representing the fluid level measured from the ground surface and the abscissae representing the pressure on the liquid surface in pounds per square inch, the point L1 determined from the preceding formula may be plotted on the chart shown in Fig. 3.

Now, the valve 12 is closed or a suitable pressure regulator is placed in the gas line 11 and the pressure within the casing is allowed to build up to any predetermined value. As the pressure builds up, the oil level 3 tends to recede. By continuing the operations of the pump during the building up of this pressure, preferably for a period substantially equal to three times the length of time required for the pump to remove the column of fluid between the original fluid level and a new fluid level to which the pressure depresses the liquid surface, represented at 3a (Fig. 2), it will be found that a stable condition will be achieved at which the fluid level will become constant and

Defendant's Exhibit R—(Continued)

the production by the pump will be approximately the same as before the pressure was allowed to build up in the casing. When this stable condition is reached, a second measurement of the fluid level is obtained by the level measuring methods and apparatus hereinbefore described.

Having determined the new location of the liquid surface, the pressure exerted thereon may now be calculated as follows: Assuming that the casing head pressure in this instance was adjusted to 170 pounds, to this should be added the pressure due to the weight of the column of gas above the new fluid level. The determination of the effect of the weight of the column of gas upon the fluid level may be obtained either by calculation or may be plotted out and obtained from suitable charts prepared for this purpose. In this instance, it may be assumed that the pressure due to the gas column is 30 pounds per square inch, making a total of 200 pounds per square inch on the fluid. Now, assuming that the level to which the standing column of liquid mixture of oil and gas has receded as 3966 feet from the top of the well, the new point L2 on the chart shown in Fig. 3 representing the new level and the pressure on the liquid surface may be placed upon the chart. From an exhaustive series of actual tests, it has been discovered that the relation between the pressure on the liquid surface and the distance through which the fluid will recede in any given well having a uniform cross sectional area is constant, so that a line drawn on the

Defendant's Exhibit R—(Continued)

chart shown in Fig. 3 intersecting the points L1 and L2 will truly represent the fluid level at any of the pressures which may be placed upon the fluid column. Thus, by merely extending the line C downwardly on the chart until it crosses the ordinate representing the location of the pump inlet indicated on the chart as A, a direct reading of the fluid pressure required to cause the surface of the column to recede to the pump inlet is obtained. On the chart this is represented as 336 pounds per square inch, which is the pressure at the pump for the normal rate of production, assuming that the rate of production was normal during the tests.

The actual pressure in the column of liquid at the pump inlet may, however, be calculated from the information received by the two fluid level tests described above. That is, by subtracting the original fluid level from the new fluid level, the total difference in level will be found, in this instance 866 feet. Then, by subtracting the original pressure on the liquid surface from the new pressure on the liquid surface, a difference of 160 pounds per square inch is found to have been necessary to cause the liquid column to recede 866 feet. By dividing the difference in fluid pressure by the difference in surface level, the density of the liquid mixture of oil and gas in the well (that is, the pressure exerted by this mixture per unit of height of the column of liquid mixture) may be found. In this instance, the column receded a distance be-

Defendant's Exhibit R—(Continued)

tween 3100 feet and 3966 feet or a total distance of 866 feet, while the pressure difference is 160 pounds. The density of the liquid is such therefore as to exert 0.185 pounds per square inch per foot of height of the column.

Hence, knowing the pressure on the fluid surface at any level thereof and knowing the distance below this surface at which the pump inlet is located, a direct calculation of the fluid pressure at the pump inlet may be obtained by the following formulae:

The pressure at any point below the normal fluid level in a well at which the level can be maintained by means of gas pressure in the casing is

$PL1 = Pc1 + Pg1$ and $PL2 = Pc2 + Pg2$

The density of the fluid for the rate of production during the tests is

$$D = \frac{PL2 - PL1}{L2 - L1} = \text{density of the fluid in lbs. per sq. in. per ft. of fluid.}$$

The pressure at the pump is

$$Pa = D(La - L2) + PL2$$

Where

Pc1 = gage casing pressure to maintain fluid at level L1.

Pc2 = gage casing pressure to maintain fluid at level L2.

Pg1 = pressure exerted upon fluid surface by weight of gas above it at level L1.

Pg2 = ditto for level L2.

PL1 = pressure on the fluid surface at level L1.

Defendant's Exhibit R—(Continued)

PL2 = pressure on the fluid surface at level L2.

L1 = fluid level corresponding to Pcl.

L2 = fluid level corresponding to Pc2.

La = pump location in feet from ground surface.

Pa = pressure at the pump.

In the example shown in Fig. 3, assuming the inlet to the pump is located at the 4700 foot level, the pressure of the oil at this point would be equal the sum of the gas pressure at the casing head for level L2, the pressure exerted by the column of gas above the liquid surface corresponding to this level and the pressure exerted by the column of oil above the pump inlet. In this instance, the pressure at the casing head is assumed to be 170 pounds per square inch, the effect of the column of gas at this pressure with the fluid level at 3966 feet from the surface being 30 pounds per square inch and the effect of the column of liquid above the pump inlet being 734 feet at the .185 pounds per square inch per foot, or 135.5 pounds per square inch exerted by the column of liquid, the result being 335.5 pounds per square inch pressure at the pump entrance. This result is clearly illustrated in Fig. 3 by the point A, the point A being located at the 335.5 pounds mark on the abscissae of the chart. If desired, an estimation of the bottom hole pressure may also be made by continuing the line C downwardly on the chart to intersect the ordinate representing the bottom of the well, such point being indicated at B, or the pressure at any other level in the well below the surface of

Defendant's Exhibit R—(Continued)

the liquid for the rate of production at which the tests were made may be located along the line C. I have discovered that in wells employing mechanical pumps for any given production rate by the pump, the density of the oil and gas mixture is constant throughout the height of the standing column of liquid in the annular space between the tubing and casing so that the line C once established continues as a straight line, the effect in pressure per unit of height of the column being constant throughout the height of the column.

Knowing the density of the oil and the pressure exerted at the pump inlet, the operator of any particular well may determine whether or not it is practicable to increase the amount of fluid being produced. If the volumetric efficiency of the pump is low and the tests indicate considerable pressure at the pump, he may raise the pump to a level indicated upon the line C at which better separation of gas will usually occur prior to entry of fluid into the pump.

The utilization of the information obtained by the foregoing method will also accurately produce the information of the maximum potential production of the well as by comparing the pressure of the fluid at the pump under two or more different operating conditions of the pump. For example, the static fluid pressure at the pump when the pump is not operating may be measured and compared with the fluid pressure at the pump when

Defendant's Exhibit R—(Continued)

the pump is operating at its normal rate of production, a comparison of the two values so obtained will produce a constant, indicating the ratio between the rates of production and pressure at the pump inlet, so that by employing this constant at a theoretical zero pump inlet pressure (which would represent the fluid being removed from the well at the rate it flows into the well from the formation) the maximum potential capacity of the well may be found.

Employing the method of determining fluid pressure at the pump hereinbefore described, the static liquid pressure may be readily obtained without necessitating the use of pressure recorders or other devices requiring the removal of or alteration of any of the pumping mechanism and the measurement may be made in wells which have been shut down as readily as in wells which are actively producing.

To obtain the fluid pressure at any point at or below the liquid surface when the well is not producing fluid, the casing should be closed in and the gas escaping from the liquid should be allowed to build up pressure in the casing until a suitable condition is reached, that is, a point is reached at which no more gas is made by the well (no more gas escapes from the liquid). When this point is reached, the remaining fluid in the well may be considered as dense fluid.

Now, by determining the height of the liquid surface under these conditions by my method, the

Defendant's Exhibit R—(Continued)

pressure on the liquid surface may be readily determined and by adding thereto the effect of the weight of the column of fluid above any given level, the fluid pressure at that level may be found. This information alone is extremely useful to the operators of producing wells.

The information thus obtained may be plotted on a graph or chart such as that shown in Fig. 4, wherein the ordinates represent fluid pressure at the pump inlet in pounds per square inch and the abscissae represent rate of production of oil from the particular well under consideration, and the static pressure may be plotted at zero production, as indicated by the point D in Fig. 4.

The casing pressure may now be reduced and the pump started and allowed to assume a predetermined rate of production, preferably its normal rate. Assuming this rate is 200 barrels of oil per day, a new determination of the fluid pressure at the pump is made at this rate of production. That is, the pump is started and allowed to operate until the fluid level in the well reaches a stable condition. The location of the fluid level and the pressure in pounds per square inch at the pump inlet under these conditions are determined by the method hereinbefore described and the fluid pressure at the pump is plotted against the production rate on the chart shown in Fig. 4. Assuming that this new pressure at 200 barrels per day is found to be at the point indicated in Fig. 4 at E, a straight line drawn between the points D

Defendant's Exhibit R—(Continued)

and E will intersect the zero pressure ordinate at a point representing the maximum potential capacity of the well. In the diagram shown in Fig. 4, this maximum potential production capacity is found to be 300 barrels per day. In other words, if a pump of sufficient capacity is installed in this well and operated in such manner as to remove 300 barrels per day, the oil will be removed at the same rate at which it flows from the well from the formation.

A more accurate determination of the maximum potential production capacity of the well may be made by comparing the fluid pressure at the pump under two different operating conditions of the pump, such as by measuring the fluid pressure at the pump when the pump is operating at one production rate, for example its normal rate, and then changing the rate of production of the pump as by slowing the pump down or changing the stroke of the pump and plotting the relation between the new production rate and the fluid pressure measured by my method, as set forth herein, it will be found that a line intersecting these two points will also represent the relation between production rate and fluid pressure at the pump at any rate of production by the pump. As shown in Fig. 5, the normal production rate of 200 barrels per day plotted against the fluid pressure at the pump in pounds per square inch may be represented upon the chart by the point G while at a reduced rate of

Defendant's Exhibit R—(Continued)

production at the pump, say to 100 barrels per day, it will be found that the fluid pressure at the pump is increased so that by determining the fluid pressure under these conditions, the relation between the reduced production rate and the fluid pressure at the pump may be plotted by the point H. A straight line interconnecting the points H and G will intersect the zero pressure ordinate at a point therealong, indicating a maximum possible production of 300 barrels per day. In making such determinations, however, it is desirable that the rate of production of the pump be reduced to at least two thirds of its normal production rate and preferably to 50% of its normal production rate in order to obtain substantially widely separated points H and G.

Again, it will be noted that all of the necessary calculations to determine the maximum production possible of the well may be made without interrupting the normal production conditions at the well and without requiring the laborious efforts of removing and replacing any of the pump mechanisms.

It will therefore be observed that I have provided a ready method for determining the density of the fluid in any particular well and also for the determination of the fluid pressure at the pump without requiring the removal or alteration of any of the usual mechanism found in the well. It will also be noted that I have provided a ready method for graphically determining the fluid pres-

Defendant's Exhibit R—(Continued)

sure at the pump by first determining the amount of recession of the fluid level due to changes in gas pressure exerted upon the fluid surface and plotting this information upon a graph or chart and extending a straight line intersecting the two or more points so located to a point on the chart representing the level of the pump inlet. It will also be noted that I have devised a ready means of utilizing the information obtained with respect to fluid levels and gas pressures at the casing head for mathematically determining the fluid pressure at the pump and also for utilizing this information to determine accurately the potential production of any well measured. It should also be noted that all of the measurements necessary to provide for the computations and calculations explained herein may be accomplished without interrupting the operation of the pump except for the measurement of the static pressure as described herein.

While I have illustrated and described the preferred embodiment of my invention, I do not desire to be limited to any of the detail illustrated or described herein, except as defined in the appended claims.

WM:MM

I CLAIM:

1. The method of determining the density of the standing column of liquid in a well, which comprises measuring the stable level of the liquid column under one condition of gas pressure, changing the pressure of gas within the well to move the

Defendant's Exhibit R—(Continued)

surface of the liquid to a new stable level, measuring the new stable level and dividing the change in pressure on the liquid surface required to achieve the new level by the difference in height between the two levels.

2. The method of determining the density of liquid in a well having a casing and a pump suspended therein on tubing and without requiring removal of pump parts, which consists in determining the liquid level in the annular space between the pump tubing and the casing under one condition of pressure, changing the pressure of the gas within the well to move the liquid surface to a new stable level, measuring the new level and dividing the change in pressure on the fluid surface required to achieve the new level by the difference between the two levels.

3. The method of determining the density of the standing column of liquid in a well having a casing and a pump suspended therein, which consists in measuring the level of the standing column of liquid in the well while the pump therein is operated at a given rate of production and under a known condition of gas pressure on the surface of the liquid column, changing the gas pressure on the liquid column, continuing the operation of the pump at the same production rate until the level of the standing column becomes stable at a new location, measuring the new level and comparing the difference in the pressures exerted on the liquid

Defendant's Exhibit R—(Continued)

surface at the two levels with the difference in height of the two levels.

4. The method of determining the density of the standing column of liquid in a well having a casing and a pump suspended therein, which consists in measuring the stable level of the surface of the standing column of liquid under one condition of pressure of gas released by the well, measuring the pressure on said liquid surface under said one condition of gas pressure, regulating the flow of gas from the well to increase the pressure of said gas to a different value to depress the surface of said standing column to a new stable level, measuring the new level, measuring the pressure on the liquid surface at the new level, and comparing the difference in the pressures exerted upon the liquid surface under the two conditions of gas pressure with the difference in height of the levels of the liquid surface under the two pressure conditions.

5. The method of determining the density of the standing column of liquid in an oil well having a casing and a mechanical pump suspended therein upon pump tubing and without requiring the removal of pump parts which consists in the steps of operating the pump under one stable condition of gas pressure in the casing until the liquid level becomes stable, measuring the distances between the casing head and the surface of the liquid under this stable condition, altering the casing pressure to a new condition, operating the pump at the same rate of production under the new condition of gas

Defendant's Exhibit R—(Continued)

pressure to again stabilize the liquid level, measuring the distance between the casing head and the new level of the liquid surface under said new stable condition, and measuring the casing head pressures under the two stable conditions, whereby the pressure exerted by the liquid per unit of height of the liquid is represented by comparing the difference in height of the liquid surface levels and the difference between the pressures on the liquid surface required to maintain the liquid surface at the two levels.

6. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted in the standing column of liquid in the well at any desired level below the normal surface of said column and without requiring the removal of any of the pump parts, which comprises measuring the actual stable level of the liquid column under one known condition of gas pressure in the casing, determining the pressure on the liquid surface at that level, changing the pressure of gas in the well to move the surface of said column to a new actual stable level, measuring the new level of the liquid surface, determining the pressure on the liquid surface at the new level, determining the density of the liquid by dividing the change in pressure on the liquid surface required to achieve the new level by the differnce in height of the two levels and computing the unknown pressure at the desired level by adding to the pressure on the liquid surface at either of the

Defendant's Exhibit R—(Continued)

levels the effect in pressure of the column of liquid of the density so determined between the selected actual level and the desired level.

7. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted by the standing column of liquid at any desired level below the normal surface of said column while the pump is operating to remove liquid from the well, which comprises measuring the actual stable level of the liquid under one known condition of gas pressure in the well by sonic sounding method, determining the pressure on the liquid surface at that level, changing the pressure of the gas in the well to move the surface of the column to a new actual level, continuing to operate the pump at the same production rate as for the first condition of gas pressure in the well until the liquid level again becomes stable, measuring the new stable level and determining the pressure upon the liquid surface at this new level, determining the pressure exerted per unit of height of the liquid column by dividing the change in gas pressure on the liquid surface required to effect the change in the liquid level by the difference in height of the two levels, and computing the unknown pressure at the desired level by adding to the gas pressure upon the liquid surface at either of the actual levels the effect in pressure of the liquid column between the selected actual level and the desired level.

8. The method of determining the potential pro-

Defendant's Exhibit R—(Continued)

duction capacity of a well having a casing and a pump suspended therein, which comprises measuring the stable level of the surface of the standing column of liquid in the well at one known rate of production and under one known condition of gas pressure in the well, determining the pressure on the surface of the liquid column at that level, changing the gas pressure in the well to move the surface of the liquid column to a new stable level, measuring the level of the liquid surface under the new gas pressure condition and determining the pressure on the liquid surface at the new level, dividing the change in pressure on the liquid surface by the difference in height between the two levels to thereby determine the density of the liquid in the column at that rate of production, determining the pressure at some predetermined desired point below the normal liquid surface for that rate of production by adding to the pressure on the liquid surface for either of the measured levels the effect in pressure of the column of liquid between that level and the predetermined desired point, then changing the rate of production by the pump and repeating the liquid level change and gas pressure determinations to determine the density of the liquid in the column and the pressure of the liquid at the said predetermined desired point for the new rate of production and then dividing the difference in the two production rates by the difference in the corresponding liquid pressures at the desired point and using the ratio thus

Defendant's Exhibit R—(Continued)

found to determine the maximum rate at which the well is capable of being produced.

In testimony whereof I affix my signature

CRANFORD P. WALKER.

OATH

State of California
County of Los Angeles—ss.

Cranford P. Walker, the above named petitioner, being duly sworn, deposes and says that he is a citizen of the United States, and resident of San Marino, in the County of Los Angeles, State of California, that he verily believes himself to be the original, first and sole inventor or discoverer of the Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells, described and claimed in the annexed specifications; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to the filing of his parent application for United States Letters Patent, Serial No. 171,170 of which this application is a continuation, or in public use or on sale in the United States for more than two years prior to the said parent application; that said invention has not been patented in any country foreign to the United States on any application filed by him or his legal representatives or assigns more than twelve months

Defendant's Exhibit R—(Continued)

prior to this application; and that no application for patent on said invention has been filed by him or his legal representatives or assigns in any country foreign to the United States.

CRANFORD P. WALKER

Subscribed and sworn to before me, this 14th day of April, 1939.

[Seal] MARJORIE McKAY

Notary Public in and for the County of Los Angeles, State of California.

My Commission Expires July 14, 1941.

Defendant's Exhibit R—(Continued)
Div. 36 Room 7892
Buchler:mwc
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name
Paper No. 3
All communications respecting this
application should give the serial number
date of filing, and name of
the applicant
254
Department of Commerce
United States Patent Office
Washington

Mailed Apr 28 1939

Please find below a communication from the Examiner in charge of this application

CONWAY P. COE
Commissioner of Patents.

Harold W. Mattingly,
720 Pacific Finance Bldg.,
621 S. Hope Street,
Los Angeles, California.

Ser. No. 268805
Filed Apr. 19, 1939
For Method of Determining Fluid Density,
Fluid Pressure and the Production
Capacity of Oil Wells

In accordance with the provisions of Order

Defendant's Exhibit R—(Continued)

No. 2308, dated March 12, 1917, which reads in part as follows:

* * * * * *

> Obvious informalities in the application may be corrected by the examiner, but said correction must be in the form of an amendment, approved by the Principal Examiner in writing, placed in the file, and made a part of the record. The changes specified in the amendment will be entered by the clerk in the regular way.

* * * *

the changes, hereinafter specified, are made by the examiner in the application above identified.

Should these changes not be satisfactory to the applicant, appropriate amendment may be proposed under the provisions of Rule 78, provided the specification has not been printed.

The application has been amended as follows:

In Fig. 4, Pump has been substituted for "Top".

Corrected. M. B. Div. 36. April 27, 1939.

A. D. McFADYEN

Examiner.

401

Div. 36.

TITLE REPORT

No. 268,805, Continuation of Ser. No. 171,170.

Name Cranford P. Walker.

Defendant's Exhibit R—(Continued)

The title appears from the assignment records to be vested in:

The Inventor.

Examined up to and including Apr. 18, 1939.

This certificate dated May 3, 1939.

H. C. SPIELMAN

Asst. Chief of Assignment Division.

No further assignments appear to have been received for record including Apr. 29, 1939.

Address only

The Commissioner of Patents

Washington, D. C.

Serial No. 268805

Mailed May 8 1939.

Div. 36 - Rm 7892 - mwc

Department of Commerce

United States Patent Office

Washington

May eighth, 1939

Cranford P. Walker,

Your Application for a patent for an Improvement in Method of Determining Fluid Density Fluid Pressure and the Production Capacity of Oil Wells filed Apr. 19, 1939 has been examined and Allowed with 8 claims.

The final fee, Thirty Dollars, With $1 Additional for Each Claim Allowed in Excess of 20, must be

Defendant's Exhibit R—(Continued)

paid not later than Six Months from the date of this present notice of allowance. If the final fee be not paid within that period, the patent will be withheld, but the application may be renewed within one year after the date of the original notice, with a renewal fee of $30 and $1 additional for each claim in excess of 20.

The office delivers patents upon the day of their date, on which date their term begins to run. The preparation of the patent for final signing and sealing will require about four weeks, and such work will not be begun until after payment of the necessary final fee.

When the final fee is paid, there should also be sent, Distinctly and Plainly Written, the name of the Inventor, Title of the Invention, and Serial Number as Above Given, Date of Allowance (which is the date of this circular), Date of Filing, and, if assigned, the Names of the Assignees.

If it is desired to have the patent issue to an Assignee or Assignees, an assignment containing a Request to that effect, together with the Fee for recording the same, must be filed in this office on or before the date of payment of the final fee.

After issue of the patent, uncertified copies of the drawings and specifications may be purchased at the price of Ten Cents Each. The money should accompany the order. Postage stamps will not be received.

The final fee will Not be received from other than

Defendant's Exhibit R—(Continued)

the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

Notice.—When the number of claims allowed is in excess of 20, no sum less than $30 plus $1 additional for each claim in excess of twenty can be accepted as the final fee.

Respectfully,

CONWAY P. COE

Commissioner of Patents.

Harold W. Mattingly,
720 Pacific Finance Bldg.,
621 S. Hope Street,
Los Angeles, California.

[Printed in margin]: In Remitting the Final Fee Give The Serial Number at the Head of this Notice.

[Printed in margin]: Uncertified Checks Will Not Be Accepted.

Defendant's Exhibit R—(Continued)

May-11-39 229438 D — Check — 30.00.

327

FINAL FEE PAID TO THE COMMISSIONER OF PATENTS

(Be careful to give correct Serial No.)

Mail Division May 11 1939 U. S. Patent Office.

Serial No. 268805

Inventor:

Cranford P. Walker

Patent To Be Issued To

Inventor.

Name Of Invention, As Allowed:

Date Of Payment:

May 11 1939

Fee:

$30

Date Of Filing:

Apr 20 1939

Date Of Circular Of Allowance:

May 8 1939

The Commissioner of Patents will please apply the accompanying fee as indicated above.

H. W. MATTINGLY

Attorney.

Send Patent To

H. W. Mattingly

621 So. Hope St.

Los Angeles, Calif.

Defendant's Exhibit R—(Continued)

Final fees will not be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office, Nor Will They Be Applied In Pending Applications.

[Printer's Note: Copy of Patent No. 2,161,733 issued to C. P. Walker entitled Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells attached here is not reproduced, as it is set out in full as Defendant's Exhibit O-1 in this printed record.]

22-76

Patent No. 2161733

Inventor C. P. Walker

An application for reissue

of this patent was filed on Dec 4, 1939.

Reissue application abandoned on.....

Reissue Patent issued on March 5, 1940.

As Reissue No. 21,383.

Do Not removed this from file.

73/51 Oil Well

June 6, 1939. C. P. WALKER 2,161,733

METHOD OF DETERMINING FLUID DENSITY, FLUID PRESSURE, AND THE PRODUCTION CAPACITY OF OIL WELLS

Original Filed Oct. 26, 1937

O.G. FIG. 1 CLASS 73 SUB. CLASS 51

733

31/203/39

FIG. 1. FIG. 2.

FIG. 3.

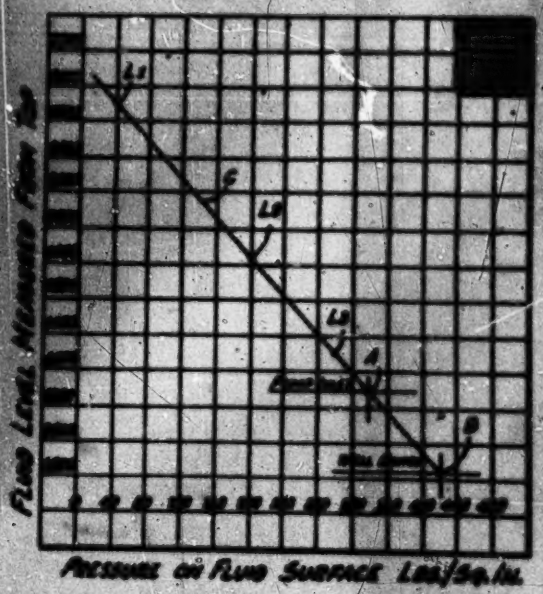


FIG. 4.

FIG. 5.

INVENTOR
CRANFORD P. WALKER

BY Harold W. Mattingly

ATTORNEY.

71

Defendant's Exhibit R—(Continued)

District Court of the United States
Southern District of California—Central Division

Honorable Commissioner of Patents,
Washington, D. C.

Sir:

In compliance with the Act of February 18, 1922 (42 Stat. L. 392), you are advised that there was filed on the 16th day of July, 1941, in this court an action, suit, or proceeding No. 1655-H-Civ., entitled:

Name Cranford P. Walker, etc., et al., Plaintiffs,
Address Los Angeles, California,

versus

Name Halliburton Oil Well Cementing Co., a Delaware corp., Defendant,

Address Los Angeles, California.

brought upon the following patents:

	Patent No.	Date of Patent	Patentee
1.	2,156,519	May 2, 1939	Cranford P. Walker
2.	2,161,733	June 6, 1939	Cranford P. Walker
3.	Reissue 21,383	Mar. 5, 1940	Cranford P. Walker

In the above-entitled case the following decision has been rendered or decree issued:

.....

In Witness Whereof I have affixed my hand this 16th day of July, 1941, at Los Angeles, Calif.

R. S. ZIMMERMAN,
Clerk of said Court.
By L. WAYNE THOMAS
L. Wayne Thomas,
Deputy Clerk.

Defendant's Exhibit R—(Continued)

421

1939

Contents

1. Application.....papers.
2. Print 4-24-39
3. Exrs Amdt A Apr-28-39
4. Appln for Reissue Dec 4, 1939
5. Notice of suit July 21-1941

[Endorsed]: Filed Nov. 9, 1942.

DEFENDANT'S EXHIBIT S

390

Department Of Commerce
United States Patent Office

To all persons to whom these presents shall come, Greeting:

This Is To Certify that the annexed is a true copy from the records of this office of the File Wrapper and Contents, in the matter of the

Reissue Letters Patent of
Cranford P. Walker,

Number 21,383, Granted March 5, 1940,

for

Improvement in Methods of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

In Testimony Whereof I have hereunto set my hand and caused the seal of the Patent Office to be

Defendant's Exhibit S—(Continued)

affixed at the City of Washington, this seventh day of November, in the year of our Lord one thousand nine hundred and forty-one and of the Independence of the United States of America the one hundred and sixty-sixth.

Attest:

[Seal] D. E. WILSON
Chief of Division.

CONWAY P. COE
Commissioner of Patents.

PATENTED FILE

RETURN TO RECORD ROOM

13682

NUMBER (Series of 1935)

307551

REISSUE NO. 21,387

DIV. 36

1939 DATED

(EX'R'S Book)

Name CRANFORD P. WALKER

of SAN MARINO

State of CALIFORNIA

Invention METHOD OF DETERMINING FLUID DENSITY, FLUID PRESSURE AND THE PRODUCTION CAPACITY OF OIL WELLS

APPLICATION FILED COMPLETE, DEC 4 1939

PARTS OF APPLICATION FILED

Petition, Specification, Oath, Fee $30, Old Patent, Abstract of Title, 1 Sheets Drawings, ORDERED DEC 4 1939

Original Patent No. 2,161,733 Date JUNE 6 1939

Examined and Passed for Issue JAN 26 1940, 193 Asst. Examiner Exr. Div. 36

Notice of Allowance JAN 26,1940, 193

By Commissioner

Attorney HAROLD W. MATTINGLY 621 S. HOPE ST LOS ANGELES CALIF.

Associate Attorney

Number of Claims Allowed 11-First Class

Title as Allowed Method of determining fluid density, fluid pressure and the production capacity of oil wells.

Commissioner of Patents
Division of Original Patents No. 174,170 Filed October 26, 1937

Defendant's Exhibit S—(Continued)

Walter P. Huntley MAdison 1137
Harold W. Mattingly
Attorney at Law
Patent and Trademark Causes
621 South Hope Street
Los Angeles, California

November 29, 1939.

Dec-4 39 185830 B — Check — 30.00

Hon. Commissioner of Patents
Washington, D. C.

Sir:

Attached is application for Letters Patent of the United States (Reissue), executed November 15, 1939 for Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells by Cranford P. Walker; also attached is my check No. 1556 in the amount of $30.00 to cover the Government filing fee (11 claims).

Also attached is original United States Letters Patent No. 2,161,733 offered for surrender.

For drawings in connection with this application, it is requested that the Patent Office transfer the original drawings from application Serial No. 268,805, of which this is a reissue, and it is further requested that photostatic prints of the said drawings be furnished for application Serial No. 268,805, the cost of which may be charged to my miscellaneous fees account.

Respectfully,

HAROLD W. MATTINGLY.

[Longhand Note]: orig. pat. herewith.

Defendant's Exhibit S—(Continued)

In The United States Patent Office

Re: United States Letters Patent No. 2,161,733

Cranford P. Walker

Method of Determining Fluid Density, Fluid Pressure, and The Production Capacity of Oil Wells

Issued: June 6, 1939

Application Filed: October 26, 1937 (Serial No. 171, 170 and 268,805.

PETITION FOR REISSUE

Hon. Commissioner of Patents
Washington, D. C.

Sir:

Your petitioner Cranford P. Walker, a citizen of the United States, and a resident of San Marino, in the County of Los Angeles, State of California, whose post office address is 2824 Carlaris Road, San Marino, California, prays that he may be allowed to surrender the Letters Patent for an improvement in Method of Determinating Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells No. 2,161,733, granted to him on June 6, 1939, and that Letters Patent may be issued to petitioner for the same invention upon the annexed amended specification.

With this petition is filed an order for making and filing a certified abstract of title as required in such cases.

My invention relates to methods of determining

Defendant's Exhibit S—(Continued)

the fluid density, fluid pressure and potential production capacity of oil wells and has particular reference to methods of determining the most desirable character of pumping equipment and manner of operating the same to permit an effieient production of oil from a given well.

This application is a continuation of my copending application Serial No. 171,170, filed October 26, 1937.

It is the common practice in oil well production activity to permit an oil well to produce as a flowing well, that is, to permit the oil to flow out at the ground surface due to the pressure in the oil formations, until the production rate reaches a considerably low value or ceases, after which gas lifting is usually attempted and continued until the production rate with gas lifting reaches a relatively low value or the production entirely ceases. At this time, and in some instances prior to any attempt to gas lift the oil, mechanical pumping devices are usually installed to lift the oil by mechanical means to the surface, these pumps usually comprising a pump barrel located at a considerable depth in the well, usually 50 to 150 feet below the surface of the well fluid in the well while it is producing, plungers or other reciprocating devices being employed in the barrel and operated from the ground surface by means of sucker rods.

Usually the selection of the size and character of the pumping equipment is determined by the production of the well during its flowing or gas lift-

Defendant's Exhibit S—(Continued.)

ing life by estimating from this production the type or character of pump which appears to be most suitable. In many fields, however, the type, size and character of the pump installed is usually one determined as "standard" for that particular type of well in the particular field. In other words, it is one having the same dimensions as pumps in other wells producing from the same horizon. Frequently, such well receives no further attention until the field as a whole has declined to a point where it becomes necessary to increase the production from the wells, as for example, by the encroachment of water, necessitating the lifting of greater quantities of liquid in order to obtain the desired amount of oil. When this condition occurs, it is customary to increase the capacity of the pumping equipment.

Also, the production from a given well may be believed to be less than the character of the well and the character of the pumping equipment employed should indicate, as for example, the pump may be operating at a relatively low volumetric efficiency. As is well understood, the column of well fluid extending up into the well bore is a mixture of dense oil and gas entrained therewith and the maximum volumetric efficiency of the conventional pumping equipment is attained when the pump inlet is located along this column at such place as will permit a maximum amount of dense liquid to flow into the pump upon each stroke. Thus if the

Defendant's Exhibit S—(Continued)

pressure in the column at any point below the surface of the column can be determined, the pump inlet may be so properly located as to allow it to take in a minimum quantity of gas upon each stroke. At this point it should be noted that wherever in the following description the expression "fluid", "fluid surface", "fluid level", are used, the word "fluid" is intended to refer to the natural well fluid which comprises a mechanical mixture of dense liquid, (either oil or oil and water) with such quantities of gas entrained therein as may be present in the particular well under consideration.

In order to determine whether or not any change in the size, character, operating characteristics or location of the pumping apparatus should be made, it is desirable that the location of the fluid surface, the character of the fluid in the well, its density and the fluid pressure exterted at any given point below the surface of the fluid and the maximum potential production capacity of the well should be determined. For example, if the pumps in a particular field are operating at good volumetric efficiency, much can be determined from the quantity of oil produced and the volumetric displacement per stroke of the pump, and if the pumps are operating at their maximum capacity, the fact that the fluid level is at a considerable distance above the pump inlet may indicate that the operator is justified in making a change in the size or character of the pumping equipment. Again,

Defendant's Exhibit S—(Continued)

if the volumetric efficiency of the pump is found to be low, as for example, when the pump appears to be taking in a comparatively large quantity of gas upon each stroke of the pump, the operator should know whether or not the inlet of the pump is located at a point too near the fluid surface so that he may determine how far below the fluid surface he should lower the pump in order to allow it to receive dense fluid for the full stroke.

Frequently in wells where the quantity of gas produced by the well is relatively small, an increased production of the pump may be obtained by raising the pump to a point nearer the fluid surface so that a better separation of the gas takes place prior to the entry of the fluid into the pump, while if the well is making a large quantity of gas, it may be better to lower the pump to a point below where free gas enters the well bore, if this is possible, so that upon each stroke of the pump, dense liquid will be picked up. However, in many instances, it is dangerous to lower the pump too close to the bottom as sand is likely to be pumped into and foul the pump.

In wells where the fluid level is so low that the pump is not completely submerged and hence does not receive a full cylinder, or barrel of fluid upon each stroke, a pounding at the pump is created which may be heard or determined at the ground surface. This same character of pounding, however, may be produced by the pump even though the fluid surface is at a considerable distance above

Defendant's Exhibit S—(Continued)

the pump inlet, occasioned by the inflow into the pump of large quantities of free gas. Hence, simple tests to determine the fluid level relative to the pump inlet will show which of these two conditions exists but will not produce the desired information to the operator as to the desirable character or location of the pumping mechanism.

If, however, the fluid pressure at different levels below the surface of the fluid is determined, this information may be employed to determine the most desirable location of the pump and whether or not a change should be made in the size, operating characteristics or character of the pumping equipment employed in a given well to produce an increased or maximum production from the well.

The determination of the fluid pressure at different points below the surface of the well fluid may be determined by instruments known as pressure recorders, which must be either attached to the pump or lowered into the well to the desired level, or must be lowered into the well on wires, cables or other supporting devices and left at the desired levels for a predetermined length of time necessary to permit the recorders to make a chart or record of the pressures encountered. All of these methods, however, required the stopping of the pumps and the stopping of production while the test is being made and further required the removal of the pumps and sucker rods and sometimes the tubing and other apparatus from the

Defendant's Exhibit S—(Continued)

well in order to insert the pressure recorders or pressure measuring devices, which entailed considerable labor and time and held up the production of the well for a considerable period of time.

It is therefore an object of my invention to provide methods for determining the fluid pressure at any given point below the surface of the column of well fluid which extends up into the space between the casing and the pump tubing (known as the 'standing column'), determining the density of the fluid in such column and the production index of the well without interrupting or interferring with the production of the well by the usual pumping apparatus employed therein.

Another object of my invention is to provide a ready means for determining the fluid pressure at any level below the surface of the standing column of fluid in the well and for determining the density of the well fluid in any particular well without necessitating the removal or replacement of any of the usual pumping apparatus, flow tubes, sucker rods or other mechanism found in a well being produced by a mechanical pump.

Another object of my invention is to provide information to aid in the determining of the proper location of the pump in an oil well to achieve the maximum volumetric efficiency of the pump in handling the particular c haracter of well fluid found in the particuar well.

Another object of my invention is to provide a ready method for determining the potential pro-

Defendant's Exhibit S—(Continued)

duction capacity of an oil well with a minimum of expense, delay or interruption of the production activities of the well.

Another object of my invention is to provide a method of determining the density of the fluid in a well by measuring the amount of recession of the level of the fluid surface under two or more conditions of pressure upon the fluid surface and computing from the facts thus obtained the density of the fluid in the well. Fluid densities in producing wells range all the way from less than .04 pound per square inch to over .4 pound per square inch per foot of fluid in the well. Therefore, a simple fluid level determination without a density or pressure determination gives very little information.

Another object of my invention is to provide a ready method for determining the potential production capacity of a well by measuring the pressure at the pump inlet under two conditions of operation of the pump and computing therefrom the maximum potential production obtainable from the well.

Another object of my invention is to provide a ready method for determining the potential production capacity of a well by determining the fluid pressure at some point below the fluid surface in the well, either at the pump inlet or any other location, under two conditions of production from the well (one of which may be zero production), and by

Defendant's Exhibit S—(Continued)

comparing the pressures so determined with the production rates, determining the maximum potential production obtainable from the well.

Other objects of my invention will be apparent from a study of the following specification read in connection with the accompanying drawing, wherein

Fig. 1 is a diagrammatic, cross-sectional view of a typical oil well, illustrating the level of the fluid surface as being located a considerable distance above the inlet of the pumping apparatus employed;

Fig. 2 is a view similar to Fig. 1 but illustrating the effect on the fluid surface of gas pressure allowed to build up in the casing;

Fig. 3 is a diagrammatic view illustrating a chart or graph which may be employed in the practice of my method for the computation of fluid density and pressures at different locations or levels within the well;

Fig. 4 is a diagrammatic view illustrating a chart or graph which may be employed to compute the maximum potential capacity of a well from a comparison of the pressure at the pump while it is idle with the pressure at the pump while it is operating normally; and

Fig. 5 is a view similar to Fig. 4 illustrating the manner in which a more accurate computation of the potential capacity of a well may be obtained by comparing the pressure at the pump under two production rates of the pumping apparatus.

Defendant's Exhibit S—(Continued)

Referring to the drawings, I have illustrated in Fig. 1 a typical oil well which includes a casing 1 extending down through the well bore from the ground surface 2 into the oil producing sands, the oil flowing from the sands or oil formation into the casing and rising in the casing to some level indicated at 3. Pumping apparatus employed to remove the oil from the well usually includes a suitable pump 4 located upon tubing string 5, constituting the flow tubing through which the oil is raised to the ground surface, the pump 4 including usually some reciprocating mechanism operated by reciprocal movements of a string of sucker rods 6 extending down through the tubing 5 and connected to reciprocating power apparatus at the ground surface, as indicated at 7. The flow tubing 5 is provided with an outlet 8 communicating with a suitable oil line through which the oil pumped from the well is conveyed to any desired location.

The casing 1 is closed at its upper end as indicated at 9, an outlet 10 being provided communicating with the casing 1 to permit gas escaping from the oil to pass into a suitable gas line 11, a control valve 12 being usually provided to control the flow of gas into the gas line.

By properly selecting the size, the stroke and the speed of the pump 4, the pump may be made to remove the oil from the well at approximately the same rate at which the oil flows into the well from the surrounding formation, and if so selected, the well will be operated at its maximum capacity.

Defendant's Exhibit S—(Continued)

However, oil coming from the formation contains relatively large quantities of gas which, due to the pressure of the oil, cannot readily escape and is drawn into the pump with the oil, thereby reducing the liquid volumetric efficiency of the pump.

I have discovered a ready means for ascertaining the pressure existing at the pump entrance or at any other point below the surface of the standing column of well fluid in any given well without requiring the removal of the pump or any of its parts, and I have also discovered a ready method for determining the density of the well fluid, the information so obtained being used to select the location of the pump at the most desirable level and for use in determining the production capacity of the well.

To obtain the information required, I measure or determine the stable location of the fluid surface of the "standing column" of fluid within the well when the pump is operating at its normal production capacity and with the pressure of gas within the casing at the usual or normal value maintained during the usual or normal pumping operations at the well. The expression "standing column" as used herein is intended to mean the column of well fluid which stands in the well as distinguished from the pumped liquid column which is being lifted to the ground surface by the pump, such standing column being known in the oil industry as the "dead" fluid column, and with the usual type of

Defendant's Exhibit S—(Continued)

pumping apparatus this standing column lies in the annular space between the tubing 5 and the casing 1.

This location of the fluid level may be readily accomplished by employing the methods and apparatus disclosed In United States Letters Patent No. 2,047,974, issued to Harold T. Wyatt and Paul E. Lehr, July 21, 1936, and in United States Letters Patent No. 2,156,519, issued to me on May 2, 1939, and in my copending application Serial No. 164,534, filed September 18, 1937. While the methods and apparatus are completely disclosed in the said patents and application, the method may be stated briefly as including the introduction into the annular space between the tubing 5 and the well casing of a sudden change in pressure in the well casing and measuring the length of time elapsing between the production of this pressure impulse and the return to the ground surface of the echo thereof from the surface of the fluid. Noting the distance from the ground surface of the fluid level under these conditions and noting the pressure of gas at the casing head, as by means of a pressure gage 13, the pressure on the fluid surface may be computed as follows: To the casing head pressure is added the effect of pressure on the fluid surface exerted by the weight of the column of gas between the fluid surface and the casing head. A gravity test may be made of the gas at the casing head which will determine the pressure exerted by each foot or

Defendant's Exhibit S—(Continued)

hundred feet of height of the gas column. This information may be computed by the following formula which is by Dice:

$$\text{Log}_{10}\text{Pb} = \frac{\text{SD}}{122.82\text{T}} + \text{Log}_{10}\text{Pt}$$

Where

Pb=Lbs. ∧ ~~sw.~~ sq. in. absolute at bottom of gas column.

Pt=Lbs./sq. in. absolute at top of gas column.

S=Specific Gravity of the gas (air is considered 1).

D=Depth from casing head to fluid surface.

T=Mean Temp. of the gas column in degrees F absolute.

This information may then be plotted upon a graph or chart as illustrated in Fig. 3 in which the conditions existing in the particular well under measurement are assumed to be such that with a pressure of 36 pounds per square inch at the casing head, the fluid surface is found to lie at 3100 feet below the casing head. The specific gravity of the gas in this instance may be found to be such that the effect will be to produce 4 pounds per square inch pressure on the fluid surface. Thus, the addition of 36 pounds and 4 pounds produces a total pressure on the fluid surface of 40 pounds per square inch. By arranging the chart shown in Fig. 3 with the ordinates representing the fluid level measured from the ground surface and the abscissae representing pressure on the fluid surface in pounds per square inch, the point L1 determined

Defendant's Exhibit S—(Continued)

from the preceding formula may be plotted on the chart shown in Fig. 3.

Now the valve 12 is closed or a suitable pressure regulator is placed in the gas line 11 and the pressure within the casing is allowed to build up to any predetermined value. As the pressure builds up, the fluid level 3 tends to recede, the pump drawing down the fluid column until a stable condition of production and fluid level is reached under the new gas pressure. By continuing the operations of the pump during the building up of this pressure, preferably for a period substantially equal to three times the length of time required for the pump to remove the column of fluid between the original fluid level and a new fluid level to which the pressure depresses the fluid surface, represented at 3a (Fig. 2), a stable condition will be achieved at which the fluid level will become constant and the production by the pump will be approximately the same as before the pressure was allowed to build up in the casing. When this stable condition is reached, a second measurement of the fluid level is obtained by the level measuring methods and apparatus hereinbefore described.

Having determined the new location of the fluid surface, the pressure exerted thereon may now be calculated as follows: Assuming that the casing head pressure in this instance was adjusted to 170 pounds, to this should be added the pressure due to the weight of the column of gas above the new fluid

Defendant's Exhibit S—(Continued)

level. The determination of the effect of the weight of the column of gas upon the fluid level may be obtained either by calculation or may be plotted out and obtained from suitable charts prepared for this purpose. In this instance, it may be assumed that the pressure due to the gas column is 30 pounds per square inch, making a total of 200 pounds per square inch on the fluid surface. Now, assuming that the level to which the standing column of fluid has receded is 3960/3966, feet from the top of the well, the new point L2 on the chart shown in Fig. 3 representing the new level and the pressure on the fluid surface may be placed upon the chart.

From an exhaustive series of actual tests I have discovered that in any given well which is being produced by a mechanical pump and where the cross sectional area of the standing fluid column is constant, there is a constant relation between a change in the pressure upon the fluid surface and the corresponding change in the location of the stable fluid surface for any given rate of production. This result follows from the fact, as I have discovered, that even though large quantities of gas bubbles are usually flowing vertically through the fluid column in a pumping well, the density of the gas and oil mixture in the column is constant throughout the height of the column. This is contrary to the usual concept of the fluid density in producing oil wells as heretofore it has been possible to explore, usually with a pressure recorder, the density

Defendant's Exhibit S—(Continued)

of the fluid in flowing wells only. These measurements are usually made in the flowing column of fluid where, on account of gas breaking out of the liquid as it flows up to regions of lower pressure, the fluid density is found to increase with the depth to which the pressure recorder is run in the column. Under equilibrium conditions in wells being produced by mechanical pumps there is evidently very little gas liberated from the liquid in the standing column, therefore the volume of gas which enters the column at the bottom is practically the same as that given off at the top. The constant density phenomena which I have discovered appears to be due to the fact that the size of the gas bubbles decreases and their density increases with their depth in the fluid column. They therefore travel much slower near the bottom than they do near the top of the fluid column where they are large and light. At the bottom therefore there are many small heavy gas bubbles traveling close together vertically upward at a slow rate whereas as these same bubbles approach the top of the column they become very large and light and travel at a high speed and are farther apart. The relations of bubble size, weight and velocity at different levels in the fluid column are evidently such that the proportions of gas and liquid are constant throughout the height of the column and the density does not change.

It follows therefore that an increase in pressure on the surface of the fluid column will cause the

Defendant's Exhibit S—(Continued)

column to recede through a distance directly proportional to the increase in pressure. Hence a line drawn on the chart shown in Fig. 3 intersecting the points L1 and L2 will truly represent the fluid level at any of the pressures which may be placed upon the column. Thus by merely extending the line C downwardly on the chart until it crosses the ordinate representing the location of the pump inlet indicated on the chart as A, a direct reading may be made from the chart of the pressure on the fluid surface which would be required to cause the surface of the column to recede to the pump inlet. On the chart this is represented as 336 pounds per square inch, which is the pressure exerted by the well fluid in that particular well at the pump entrance for the normal casing pressure and normal rate of production, assuming that the rate of production was normal during these tests.

The actual pressure in the column of fluid at the pump inlet may, however, be calculated from the information received by the two fluid level tests described above. That is, by subtracting the original fluid level from the new fluid level, the total difference in level will be found, in this instance 866 feet. Then by subtracting the original pressure on the fluid surface from the new pressure on the fluid surface, a difference of 160 pounds per square inch is found to have been necessary to cause the fluid column to recede 866 feet. By dividing the difference in fluid pressure by the difference in surface level, the density of the mixture of oil

Defendant's Exhibit S—(Continued)

and gas in the well (that is, the pressure exerted by this mixture per unit of height of the column of the mixture) may be found. In this instance, the column receded a distance between 3100 feet and 3966 feet, or a total distance of 866 feet, while the pressure difference is 160 pounds. The density of the fluid in the column is such therefore as to exert 0.185 pound per square inch per foot of height of the column.

Hence, knowing the pressure on the fluid surface at any level thereof and knowing the distance below this surface at which the pump inlet is located, a direct calculation of the fluid pressure at the pump inlet may be obtained by the following formulae:

The pressure at any point below the normal surface level in a well at which the level can be maintained by means of gas pressure in the casing is

$$PL1 = Pc1 + Pg1 \text{ and } PL2 = Pc2 + Pg2$$

The density of the fluid for the rate of production during the tests is

$$D = \frac{PL2 - PL1}{L2 - L1} = \text{density of the fluid in lbs. per sq. in. per foot of fluid.}$$

The pressure at the pump is

$$Pa = D(La - L2) + PL2$$

Where

Pc1 = gage casing pressure to maintain fluid at level L1.

Pc2 = gage casing pressure to maintain fluid at level L2.

Defendant's Exhibit S—(Continued)

Pg1 = pressure exerted upon fluid surface by weight of gas above it at level L1.

Pg2 = ditto for level L2.

PL1 = pressure on the fluid surface at level L1.

PL2 = pressure on the fluid surface at level L2.

L1 = fluid level corresponding to Pc1.

L2 = fluid level corresponding to Pc2.

La = pump location in feet from ground surface.

Pa = pressure at the pump.

In the example shown in Fig. 3, assuming the inlet to the pump is located at the 4700 foot level, the pressure of the fluid at this point would be equal to the sum of the gas pressure at the casing head for level L2, the pressure exerted by the column of gas above the fluid surface corresponding to this level and the pressure exerted by the column of fluid above the pump inlet. In this instance, the pressure at the casing head is assumed to be 170 pounds per square inch, the effect of the column of gas at this pressure with the fluid level at 3966 feet from the surface being 30 pounds per square inch and the effect of the column of fluid above the pump inlet being 734 feet at .185 pound per square inch per foot, or 135.5 pounds per square inch exerted by the column of fluid, the result being 335.5 pounds per square inch pressure at the pump entrance. This result is clearly illustrated in Fig. 3 by the point A, the point A being located at 335.5 mark on the abscissae of the chart.

If desired, an estimation of the bottom hole pres-

Defendant's Exhibit S—(Continued)

sure may also be made by continuing the line C downwardly on the chart to intersect the ordinate representing the bottom of the well, such point being indicated at B, or the pressure at any other level in the well below the surface of the well fluid for the rate of production at which the tests were made ~~and~~ may be located along the line C. I have discovered that in wells employing mechanical pumps for any given production rate by the pump, the density of the oil-and-gas mixture is constant throughout the height of the standing column of fluid in the annular space between the tubing and casing so that the line C once established continues as a straight line, the effect in pressure per unit of height of the column being constant throughout the height of the column.

Knowing the density of the well fluid and the pressure exerted at the pump inlet, the operator of any particular well may determine whether or not it is practicable to increase the amount of liquid being produced. If the volumetric efficiency of the pump is low and the tests indicate considerably pressure at the pump, he may raise the pump to a level indicated upon the line C at which better separation of gas will usually occur prior to entry of liquid into the pump.

The utilization of the information obtained by the foregoing method will also accurately produce the information of the maximum potential production of the well as by comparing the pressure of the fluid at the pump under two or more different

Defendant's Exhibit S—(Continued)

operating conditions of the pump. For example, the static fluid pressure at the pump when the pump is not operating may be measured and compared with the fluid pressure at the pump when the pump is operating at its normal rate of production or at any other rate of production, a comparison of the two values so obtained will produce a constant, indicating the ratio between the rates of production and pressure at the pump inlet, so that by employing this constant at a theoretical zero pump inlet pressure (which would represent the fluid being removed from the well at the rate it flows into the well from the formation) the maximum potential capacity of the well may be found.

Employing the method of determining fluid pressure at the pump hereinbefore described, the static pressure may be readily obtained without necessitating the use of pressure recorders or other devices requiring the removal of or alteration of any of the pumping mechanism and the measurement may be made in wells which have been shut down as readily as in wells which are actively producing.

To obtain the fluid pressure at any point at or below the fluid surface when the pump is not producing fluid, the casing should be closed in and the gas escaping from the well fluid should be allowed to build up pressure in the casing until a stable condition is reached, that is, a point is reached at which no more gas is made by the well (no more gas escapes from the well fluid). When this point is

Defendant's Exhibit S—(Continued)

reached, the remaining well fluid in the well may be considered as dense liquid.

Now, by determining the height of the fluid surface under these conditions by my method, the pressure on the fluid surface may be readily determined and by adding thereto the effect of the weight of the column of fluid above any given level, the fluid pressure at that level may be found. This information alone is extremely useful to the operators of producing wells.

The information thus obtained may be plotted on a graph or chart such as that shown in Fig. 4, wherein the ordinates represent fluid pressure at the pump inlet in pounds per square inch and the abscissae represents rate of production of oil from the particular well under consideration, and the static pressure may be plotted at zero production, as indicated by the point D in Fig. 4.

The casing pressure may now be reduced and the pump started and allowed to assume a predetermined rate of production, preferably its normal rate. Assuming this rate is 200 barrels of oil per day, a new determination of the fluid pressure at the pump is made at this rate of production. That is, the pump is started and allowed to operate until the fluid level in the well reaches a stable condition. The location of the fluid level and the pressure in pounds per square inch at the pump inlet under these conditions are determined by the method hereinbefore described and the fluid pressure at the pump is plotted against the production rate on the

Defendant's Exhibit S—(Continued)

chart shown in Fig. 4. Assuming that this new pressure at 200 barrels per day is found to be at the point indicated in Fig. 4 at E, a straight line drawn between the points D and E will intersect the zero pressure ordinate at a point representing the maximum potential capacity of the well. In the diagram shown in Fig. 4, this maximum potential production capacity is found to be 300 barrels per day. In other words, if a pump of sufficient capacity is installed in this well and operated in such manner as to remove 300 barrels per day, the oil will be removed at the same rate at which it flows into the well from the formation.

A more accurate determination of the maximum potential production capacity of the well may be made by comparing the fluid pressure at the pump under two different actual producing conditions of the pump, such as by measuring the fluid pressure at the pump when the pump is operating at one production rate, for example, its normal rate, and then changing the rate of production of the pump as by slowing the pump down or changing the stroke of the pump and plotting the relation between the new production rate and the fluid pressure measured by my method, as set forth herein, it will be found that a line intersecting these two points will also represent the relation between production rate and fluid pressure at the pump at any rate of the production by the pump.

As shown in Fig. 5, the normal production rate

Defendant's Exhibit S—(Continued)

of 200 barrels per day plotted against the fluid pressure at the pump in pounds per square inch may be represented upon the chart by the point G while at a reduced rate of production at the pump, say to 100 barrels per day, it will be found that the fluid pressure at the pump is increased so that by determining the fluid pressure under these conditions, the relation between the reduced production rate and the fluid pressure at the pump may be plotted by the point H. A straight line interconnecting the points H and G will intersect the zero pressure ordinate at a point therealong, indicating a maximum possible production of 300 barrels per day. In making such determinations, however, it is desirable that the rate of production of the pump be reduced to at least two-thirds of its normal production rate and preferably to 50% of its normal production rate in order to obtain substantially widely separated points H and G.

Again, it will be noted that all of the necessary calculations to determine the maximum production possible of the well may be made without interrupting the normal production conditions at the well and without requiring the laborous efforts of removing and replacing any of the pump mechanisms.

It will therefore be observed that I have provided a ready method for determining the density of the fluid in any particular well and also for the determination of the fluid pressure at the pump without requiring the removal or alteration of any of the usual mechanism found in the well. It will

Defendant's Exhibit S—(Continued)

also be noted that I have provided a ready method for graphically determining the fluid pressure at the pump by first determining the amount of recession of the fluid level due to changes in gas pressure exerted upon the fluid surface and plotting this information upon a graph or chart and extending a straight line intersecting the two or more points so located to a point on the chart representing the level of the pump inlet.

It will also be noted that I have devised a ready means for utilizing the information obtained with respect to fluid levels and gas pressures at the casing head for mathematically determining the fluid pressure at the pump and also for utilizing this information to determine accurately the potential production of any well measured. It should also be noted that all of the measurements necessary to provide for the computations and calculations explained herein may be accomplished without interrupting the operation of the pump except for the measurement of the static pressure as described herein.

While I have shown and described the preferred embodiment of my invention, I do not desire to be limited to any of the details illustrated or described herein, except as defined in the appended claims.

H.W.M:M.M.

I CLAIM:

1. The method of determining the density of the standing column of fluid in a well, which comprises measuring the stable level of the fluid column under one condition of gas pressure, changing the pressure

Defendant's Exhibit S—(Continued)

of gas within the well to move the surface of the fluid column to a new stable level, measuring the new stable level and dividing the change in pressure on the fluid surface required to achieve the new level by the difference in height between the two levels.

2. The method of determining the density of fluid in a well having a casing and a pump suspended therein on tubing and without requiring removal of pump parts, which consists in determining the fluid level in the annular space between the pump tubing and the casing under one condition of pressure, changing the pressure of the gas within the well to move the fluid surface to a new stable level, measuring the new level and dividing the change in pressure on the fluid surface required to achieve the new level by the difference between the two levels.

3. The method of determining the density of the standing column of fluid in a well having a casing and a pump suspended therein, which consists in measuring the level of the standing column of fluid in the well while the pump therein is operated at a given rate of production and under a known condition of gas pressure on the surface of the fluid column, changing the gas pressure on the fluid column, continuing the operation of the pump at the same production rate until the level of the standing column becomes stable at a new location, measuring the new level and comparing the difference in the pres-

Defendant's Exhibit S—(Continued)

sures exerted on the fluid surface at the two levels with the difference in height of the two levels.

4. The method of determining the density of the standing column of fluid in a well having a casing and a pump suspended therein, which consists in measuring the stable level of the surface of the standing column of fluid under one condition of pressure of gas released by the well, measuring the pressure on said fluid surface under said one condition of gas pressure, regulating the flow of gas from the well to increase the pressure of said gas to a different value to depress the surface of said standing column to a new stable level, measuring the new level, measuring the pressure on the fluid surface at the new level, and comparing the difference in the pressures exerted upon the fluid surface under the two conditions of gas pressure with the difference in height of the levels of the fluid surface under the two pressure conditions.

5. The method of determining the density of the standing column of fluid in an oil well having a casing and a mechanical pump suspended therein upon pump tubing and without requiring the removal of pump parts, which consists in the steps of operating the pump under one stable condition of gas pressure in the casing until the fluid level becomes stable, measuring the distance between the casing head and the surface of the fluid under this stable condition, altering the casing pressure to a new condition, operating the pump at the same rate of production under the new condition of gas pressure

Defendant's Exhibit S—(Continued)

to again stabilize the fluid level, measuring the distance between the casing head and the new level of the fluid surface under said new stable condition, and measuring the casing head pressures under the two stable conditions, whereby the pressure exerted by the fluid per unit of height of the fluid is represented by comparing the difference in height of the fluid surface levels and the difference between the pressures on the fluid surface required to maintain the fluid surface at the two levels.

6. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted in the standing column of fluid in the well at any desired level below the normal surface of said column and without requiring the removal of any of the pump parts, which comprises measuring the actual stable level of the fluid column under one known condition of gas pressure in the casing, determining the pressure on the fluid surface at that level, changing the pressure of gas in the well to move the surface of said column to a new actual stable level, measuring the new level of the fluid surface, determining the pressure on the fluid surface at the new level, determining the density of the fluid by dividing the change in pressure on the fluid surface required to achieve the new level by the difference in height of the two levels, and computing the unknown pressure at the desired level by adding to the pressure on the fluid surface at either of the levels the effect in pressure of the column of fluid of the density so determined be-

Defendant's Exhibit S—(Continued)

tween the selected actual level and the desired level.

7. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted in the standing column of fluid at any desired level below the normal surface of said column while the pump is operating to remove fluid from the well, which comprises measuring the actual stable level of the fluid under one known condition of gas pressure in the well by sonic sounding method, determining the pressure on the fluid surface at that level, changing the pressure of the gas in the well to move the surface of the column to a new actual level, continuing to operate the pump at the same production rate as for the first condition of gas pressure in the well until the fluid level again becomes stable, measuring the new stable level and determining the pressure upon the fluid surface at this new level, determining the pressure exerted per unit of height of the fluid column by dividing the change in gas pressure on the fluid surface required to effect the change in the fluid level by the difference in height of the two levels, and computing the unknown pressure at the desired level by adding to the gas pressure upon the fluid surface at either of the actual levels the effect in pressure of the fluid column between the selected actual level and the desired level.

8. The method of determining the potential production capacity of a well having a casing and a pump suspended therein, which comprises measur-

Defendant's Exhibit S—(Continued)

ing the stable level of the surface of the standing column of fluid in the well at one known rate of production and under one known condition of gas pressure in the well, determining the the pressure on the surface of the fluid column at that level, changing the gas pressure in the well to move the surface of the fluid column to a new stable level, measuring the level of the fluid surface under the new gas pressure condition and determining the pressure on the fluid surface at the new level, dividing the change in pressure on the fluid surface by the difference in height between the two levels to thereby determine the density of the fluid in the column at that rate of production, determining the pressure at some predetermined desired point below the normal fluid surface for that rate of production by adding to the pressure on the fluid surface for either of the measured levels the effect in pressure of the column of fluid between that level and the predetermined desired point, then changing the rate of production by the pump and repeating the fluid level change and gas pressure determination to determine the density of the fluid in the column and the pressure of the fluid at the said predetermined desired point for the new rate of production and then dividing the difference in the two production rates by the difference in the corresponding fluid pressure at the desired point and using the ratio thus found to determine the maximum rate at which the well is capable of being produced.

Defendant's Exhibit S—(Continued)

9. The method of ascertaining the pressure exerted by the well fluid at any point below the normal surface thereof, which comprises: determining the location of the fluid surface under one condition of pressure of gas on the surface, determining said gas pressure under said one condition, changing the gas pressure to move the fluid surface to a new stable level, determining the new gas pressure on the fluid surface, determining the location of the new surface level and comparing the difference in said gas pressures with the corresponding change in height of the surface level to determine the relation between them, whereby the gas pressure one the fluid surface which is required to maintain the fluid surface at any selected point may be ascertained and which pressure represents the normal pressure exerted in the fluid at said point.

10. The method of ascertaining the pressure exerted by the well fluid at any point below the surface thereof while a mechanical pump is operating in that well, which comprises: determining the stable location of the fluid surface under one condition of gas pressure in the casing of the well; determining the gas pressure on the fluid surface at that level; changing the pressure of gas in the casing to move the fluid surface to a new stable level; determining the new location of the fluid surface; determining the gas pressure on the surface at the new level; and comparing the difference between the pressures on the surface with the corresponding change in the height of the fluid surface to

Defendant's Exhibit S—(Continued)

thereby determine the relation between changes in pressure on the fluid surface and the corresponding changes in the location of said fluid surface from which relation the pressure at any selected point may be ascertained.

11. The method of determining the potential production capacity of a well having a casing and a pump suspended therein, which comprises: determining the pressure exerted by the well fluid at some selected point below the normal surface thereof under one known rate of production, by determining the location of the fluid surface under one condition of gas pressure on the surface, determining the gas pressure on the fluid surface under said one condition, changing the gas pressure to move the fluid surface to a new stable level under the same production rate, determining the new gas pressure on the fluid surface, determining the location of the new surface level, comparing the difference in said gas pressures with the corresponding change in height of the surface level, to thereby ascertain the pressure exerted at said selected point under said one rate of production; changing the rate of production from said well; repeating the steps of determining the location of the fluid surface at two stable levels and the gas pressures on said surface to maintain said levels under the new production rate to ascertain the pressure exerted at the same selected point; and comparing the difference in the production rates with the corresponding dif-

Defendant's Exhibit S—(Continued)

ference in pressures at said selected point to determine their relation from which the maximum rate of production from the well may be determined.

In testimony whereof, I affix my signature at San Marino, in the County of Los Angeles, State of California, this 15th day of November, 1939.

CRANFORD P. WALKER.

In the United States Patent Office

Re: United States Letters Patent
No. 2,161,733

CRANFORD P. WALKER

METHOD OF DETERMINING FLUID DENSITY, FLUID PRESSURE, AND THE PRODUCTION CAPACITY OF OIL WELLS

Issued: June 6, 1939
Application Filed: October 26, 1937
(Serial Nos. 171,170 and 268,805)

REISSUE OATH

State of California
County of Los Angeles—ss.

Cranford P. Walker, the above named petitioner, being duly sworn, deposes and says that he does verily believe himself to be the original, first and sole inventor of the improvement set forth and

Defendant's Exhibit S—(Continued)

claimed in the foregoing specifications, and for which improvement he solicits a patent; that deponent does not know and does not believe that the said improvement was ever before known or used; that deponent is a citizen of the United States of America and resides at San Marino, in the County of Los Angeles, State of California; that deponent verily believes that the Letters Patent referred to in the foregoing Petition and Specifications, and herewith surrendered, are inoperative or invalid for the reason that the specifications thereof are defective and insufficient and that such defect and insufficiency consists particularly in:

(1) The employment in the original specification of expressions "liquid column", "fluid column", "liquid surface", "fluid surface", "fluid level", and "liquid level" interchangeably throughout the specification, whereas in order to more accurately understand the teachings of the specification a clear line of definition should be maintained between the natural well fluid which is a compressible mechanical mixture of liquid (oil and water) and gas entrapped therein as distinguished from the dense liquid (oil or water and oil) after the gas has been separated therefrom. This defect is cured in the reissue application by accurate use of the terms "well fluid", "fluid level", "fluid surface" and "fluid column" in reference to the natural well fluid in the well and the accurate use of the expressions "liquid" or "dense liquid" to refer to the separated oil.

Defendant's Exhibit S—(Continued)

(2) The obviously incorrect statement on Page 2 of the specifications that densities range "from less than .04 pound per square inch to over .4 pound per square inch per 100 feet of fluid", when such statement should read "per foot of fluid".

(3) Failure of the original specification to include an explanation of the phenomena encountered in the column of natural well fluid in the well by which the density of the mixture of dense liquid and gas is constant throughout the height of the column. This explanation was presented to the Examiner at the oral interview but was not incorporated in the body of the specification. This explanation is incorporated in the reissue specification and avoids the erroneous impression that increase in pressure upon the fluid surface causes the fluid to be driven back into the formation when in fact this fluid under the increased pressure merely speeds up the production rate from the well until the displaced fluid has been removed by the pump whereupon stable conditions under the new ressure are resumed. This explanation assists materially in an understanding of the applicant's method and accounts for the startling results achieved by the applicant.

(4) The failure of the original specification to include the following claims:

> 9. The method of ascertaining the pressure exerted by the well fluid at any point below the normal surface thereof, which comprises: de-

Defendant's Exhibit S—(Continued)

termining the location of the fluid surface under one condition of pressure of gas on the surface, determining said gas pressure under said one condition, changing the gas pressure to move the fluid surface to a new stable level, determining the new gas pressure on the fluid surface, determining the location of the new surface level and comparing the difference in said gas pressures with the corresponding change in height of the surface level to determine the relation between them, whereby the gas pressure on the fluid surface which is required to maintain the fluid surface at any selected point may be ascertained and which pressure represents the normal pressure exerted in the fluid at said point.

10. The method of ascertaining the pressure exerted by the well fluid at any point below the surface thereof while a mechanical pump is operating in that well, which comprises: determining the stable location of the fluid surface under one condition of gas pressure in the casing of the well; determining the gas pressure on the fluid surface at that level; changing the pressure of gas in the casing to move the fluid surface to a new stable level; determining the new location of the fluid surface; determining the gas pressure on the surface at the new level; and comparing the difference between the pressures on the surface with the corresponding change in the height of the fluid

Defendant's Exhibit S—(Continued)

surface to thereby determine the relation between changes in pressure on the fluid surface and the corresponding changes in the location of said fluid surface from which relation the pressure at any selected point may be ascertained.

11. The method of determining the potential production capacity of a well having a casing and a pump suspended therein, which comprises: determining the pressure exerted by the well fluid at some selected point below the normal surface thereof under one known rate of production by determining the location of the fluid surface under one condition of gas pressure on the surface, determining the gas pressure on the fluid surface under said one condition, changing the gas pressure to move the fluid surface to a new stable level under the same production rate, determining the new gas pressure on the fluid surface, determining the location of the new surface level, comparing the difference in said gas pressures with the corresponding change in height of the surface level, to thereby ascertain the pressure exerted at said selected point under said one rate of production; changing the rate of production from said well; repeating the steps of determining the location of the fluid surface at two stable levels and the gas pressures on said surface to maintain said levels under the new production rate to ascertain the pressure exerted at the

Defendant's Exhibit S—(Continued)

same selected point; and comparing the difference in the production rates with the corresponding difference in pressures at said selected point to determine their relation from which the maximum rate of production from the well may be determined.

Deponent further says that the errors which render such patent inoperative or invalid arose from inadvertence, accident and mistake, and without any fraudulent or deceptive intention on the part of deponent; that the following is a true specification of the errors which it is claimed constitute such inadvertence, accident or mistake relied upon:

As to the omission of the explanation of the density and pressure phenomena which takes place in the practice of applicant's method, at the time the original application was filed deponent believed that the explanation of the phenomena discovered by applicant was sufficient to permit a ready understanding of the invention but that subsequent to the issue of said patent persons reading the same have questioned applicant as to this phenomena. Wherefore applicant discovered that such missing explanation if supplied would materially assist in a ready understanding of his invention.

That as to the original specification reciting the terms "fluid", "fluid surface", "liquid" and "liquid surface" interchangeably, the applicant has dscovered that persons reading the patent tend to become confused as between the natural well fluid and the dense oil or liquid.

Defendant's Exhibit S—(Continued)

That as to Claims 9 and 10 submitted herewith, these claims are directed to the same subject matter as Claim 6 of the original patent but omit the limitation of the arithmetical steps of division and addition. At the time the original patent was issued, the applicant considered that these claims were sufficiently broad in scope to cover the graphic representation and graphic comparison between the pressures and fluid levels as shown in Fig. 3 and as described in the original patent, Page 3, Column 2, Line 13 to Page 4, Column 1, Line 11, and Page 4, Column 2, Lines 21 through 38, with particular reference to the explanation of the use of the chart described in the original patent, Page 4, Column 1, Lines 7 through 17, and Page 4, Column 2, Lines 21 through 29, wherein the method of ascertaining the pressure existing at points below the liquid surface other than those to which the fluid is actually depressed but without requiring any actual computation of arithmetical divisions or additions. It was only after the patent issued and immediately prior to the filing of this reissue that applicant's attention was called to the fact that Claim 6 might require interpretation in order to insure its readability on the graphic representation shown in Fig. 3 and described in the parts of the specification noted.

With respect to new Claim 11, this claim is directed to the same subject matter as Claim 8 but, like new Claims 9 and 10, omits the limitation of

Defendant's Exhibit S—(Continued)

arithmetical calculations. Again applicant at the time the original patent issued believed that these claims were sufficiently broad in scope to cover the graphic representations shown in Figs. 4 and 5 and it was not until subsequent to the issuance of the patent and attempts to exploit the patent that this defect was called to his attention as possibly requiring interpretation of the claims to enable them to be read upon the disclosure of Figs. 4 and 5 and the description hereinbefore referred to.

That the deponent has just discovered the foregoing defects and has lost no time in making this application for reissue of said patent.

That the errors hereinbefore pointed out and so particularly specified arose from the fact that applicant considered that graphic comparisons between the values ascertained by his method and arithmetical computation employing these values were and are the equivalents of each other and it was not until in attempting to exploit the invention that it was called to his attention that a possible narrow interpretation could be placed upon these claims and applicant has immediately thereafter made this application for reissue.

CRANFORD P. WALKER

Subscribed and sworn to before me this 15th day of November, 1939.

MARJORIE McKAY

Notary Public in and for the County of Los Angeles, State of California.

My commission expires July 14, 1941.

Defendant's Exhibit S—(Continued)

Petitioner requests that the original drawings upon which his patent was granted may be used as the drawings in this reissue application.

Signed at San Marino, in the County of Los Angeles, State of California, this 15th day of November, 1939.

CRANFORD P. WALKER

(SURRENDERED)

No. 2161733

The United States of America

To All to Whom These Presents Shall Come:

Whereas Cranford P. Walker, of San Marino, California, presented to the Commissioner of Patents a petition praying for the grant of Letters Patent for an alleged new and useful improvement in

> Methods of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells,

a description of which invention is contained in the specification of which a copy is hereunto annexed and made a part hereof, and complied with the various requirements of Law in such cases made and provided, and

Whereas upon due examination made the said Claimant is adjudged to be justly entitled to a patent under the Law.

Now therefore these Letters Patent are to grant unto the said Cranford P. Walker, his heirs or

Defendant's Exhibit S—(Continued)

assigns for the term of Seventeen years from the date of this grant the exclusive right to make, use and vend the said invention throughout the United States and the Territories thereof.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington this sixth day of June, in the year of our Lord one thousand nine hundred and thirty-nine, and of the Independence of the United States of America the one hundred and sixty-third.

(Seal) CONWAY P. COE
Commissioner of Patents

Attest:

H. S. MILLER
Law Examiner.

307551

[Printer's Note: Copy of Patent No. 2,161,733, issued to C. P. Walker for Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells, attached here, is not reproduced as it is set out in full as Defendant's Exhibit O-1, in this Book of Exhibits.]

1406

D.V. 3

51 Oil Well

307551

June 6, 1939. C. P. WALKER 2,161,733

METHOD OF DETERMINING FLUID DENSITY, FLUID PRESSURE, AND THE PRODUCTION CAPACITY OF OIL WELLS

Original Filed Oct. 26, 1937

Print of drawing as originally filed.

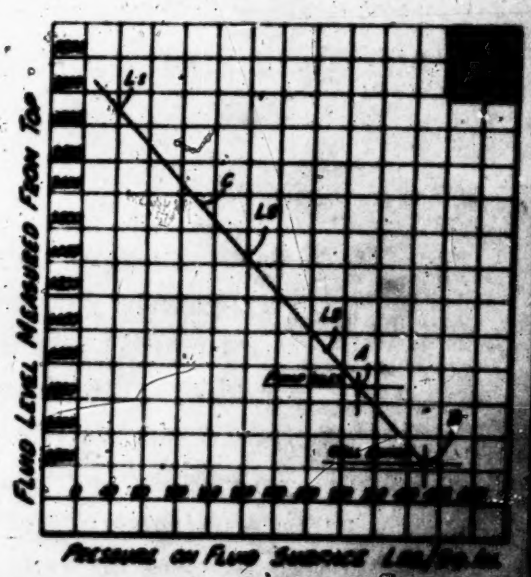
Re 383
3-5

31
288
39

FIG. 1.

FIG. 2.

FIG. 3.



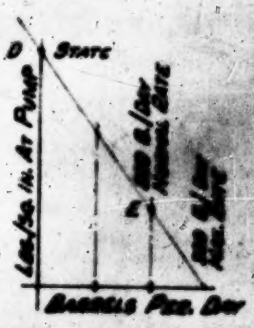


FIG. 4.

FIG. 5.

INVENTOR
CRANFORD P. WALKER

BY [signature]

ATTORNEY.

307551 41

B-51

36

CLASS ... SUB. CLASS 51

Defendant's Exhibit S—(Continued)

In the United States Patent Office

U. S. Patent Office Dec 13 1939 Division 36

Re: United States Letters Patent No. 2,161,733

Cranford P. Walker

Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells

Issued: June 6, 1939

Application Filed: October 26, 1937

(Serial Nos. 171,170 and 268,805)

ORDER FOR COPIES OF DRAWINGS

Hon. Commissioner of Patents

Washington, D. C.

Sir:

In the matter of the above entitled application for reissue Letters Patent, please furnish photostatic copies of the drawings in United States Letters Patent No. 2,161,733, granted to Cranford P. Walker on June 6, 1939, for Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells, for substitution in said patent file so that the original drawings may be used as a part of this reissue application, charging the cost of same to my Miscellaneous Fees Account.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant

Dated: November 15th, 1939.

[Longhand Note]: This letter to be placed in reissue appln. Div. 36. Ser. No. 307551.

[Longhand Note]: 1 Print ordered by appln. div. charge 20 P.

Defendant's Exhibit S—(Continued)

In the United States Patent Office

U. S. Patent Office Dec 12 1939 Division 36

Re: United States Letters Patent No. 2,161,733

Cranford P. Walker

Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells

Issued: June 6, 1939

Application Filed: October 26, 1937

(Serial Nos. 171,170 and 268,805)

POWER OF ATTORNEY

Hon. Commissioner of Patents

Washington, D. C.

Sir:

In the matter of my reissue application of United States Letters Patent No. 2,161,733, I hereby appoint Harold W. Mattingly, Registry No. 12,385, 621 South Hope Street, Los Angeles, California, my attorney with full power of substitution and revocation, to prosecute the said application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith, and request that all correspondence be conducted with said Harold W. Mattingly at the above address.

Signed at San Marino, in the County of Los Angeles, State of California, this 15th day of November, 1939.

CRANFORD P. WALKER

[Longhand Note]: No assignment of record thru Dec. 4/39.

Defendant's Exhibit S--(Continued)

Buchler/R

Div. 36 Room 7892

Department of Commerce
United States Patent Office
Washington
Paper No. 3

All communications respecting this application should give the serial number, date of filing, and name of the applicant
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name

Mailed Jan 24 1940.

Please find below a communication from the EXAMINER in charge of this application

CONWAY P. COE
Commissioner of Patents.

Harold W. Mattingly,
621 S. Hope St.,
Los Angeles, Calif.

Applicant Cranford P. Walker
Ser. No. 307,551
Filed Dec. 4, 1939
For Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells

In accordance with the provisions of Order No. 2308, dated March 12, 1917, which reads in part as follows:

* * * * * * * *

Defendant's Exhibit S—(Continued)

Obvious informalities in the application may be corrected by the examiner, but said correction must be in the form of an amendment, approved by the Principal Examiner in writing, placed in the file, and made a part of the record. The changes specified in the amendment will be entered by the clerk in the regular way.

* * * * * * * *

the changes, hereinafter specified, are made by the examiner in the application above identified.

Should these changes not be satisfactory to the applicant, appropriate amendment may be proposed under the provisions of Rule 78, provided the specification has not been printed.

The application has been amended as follows:

In line 16 of page 11, sq. has been substituted for "sw."

In line 10 of page 14, volume has been substituted for "volumn."

In line 14 of page 13, 3966 has been substituted for "3960."

In line 4 of page 18, "and" has been canceled.

A. D. McFADYEN
Examiner

Defendant's Exhibit S—(Continued)

Serial No. 307,551

Address only
Commissioner of Patents
Washington, D. C.
Department of Commerce
United States Patent Office
Washington

Cranford P. Walker,
San Marino, Calif.

Sir:

Your application for Reissue for Patent No. 2,161,733, for improvement in Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells (11 claims) has been examined and allowed.

The patent will be forwarded to you as soon as practicable, in due order of business.

Very respectfully,
CONWAY P. COE
Commissioner of Patents.

Harold W. Martingly,
621 S. Hope St.,
Los Angeles, Calif.

Mailed Jan 26 1940.
Patent Mar 5 1940 Will Issue.

Defendant's Exhibit S—(Continued)

401

Div. 36

TITLE REPORT

No. 2,161,733

Name Cranford P. Walker

The title appears from the assignment records to be vested in:

Inventor

Examined up to and including Nov. 28, 1939

This certificate dated Dec. 7, 1939

C. H. GRAY

Chief of Assignment Division.

H

No further assignments appear to have been received for record including

1/24/40.

[Printer's Note: Copy of Reissue patent No. 21,383, to C. P. Walker, for Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells, attached here, is not reproduced, as it is set out in full as Plaintiffs' Exhibit No. 2, in this Book of Exhibits].

District Court of the United States

Southern District of California—Central Division

Honorable Commissioner of Patents,

Washington, D. C.

Sir:

In compliance with the Act of February 18, 1922

Defendant's Exhibit S—(Continued)

(42 Stat. L. 392), you are advised that there was filed on the 16th day of July, 1941, ~~193~~ , in this court an action, suit, or proceeding No. 1655-H-Civ. entitled:

Name Cranford P. Walker, etc., et al., Plaintiffs,
Address Los Angeles, California,

versus

Name Halliburton Oil Well Cementing Co., a Delaware corp., Defendant,
Address Los Angeles, California.

brought upon the following patents:

	Patent No.	Date of Patent	Patentee
1.	2,156,519	May 2, 1939	Cranford P. Walker
2.	2,161,733	June 6, 1939	Cranford P. Walker
3.	Reissue 21,383	Mar. 5, 1940	Cranford P. Walker

In the above-entitled case the following decision has been rendered or decree issued:

In Witness Whereof I have affixed my hand this 16th day of July, 1941, ~~193~~ , at Los Angeles, Calif.

R. S. ZIMMERMAN,
Clerk of said Court.
By L. WAYNE THOMAS
L. Wayne Thomas, Deputy Clerk.

Defendant's Exhibit S—(Continued)

423

1939

Contents

Application . . . . . papers:

1. Print 12-8-39
2. Exr amdt A Jan. 24, 1940
3. Notice of suit July 21-1941

[Endorsed]: Filed Nov. 9, 1942.

DEFENDANT'S EXHIBIT T

390

Department of Commerce
United States Patent Office

To all persons to whom these presents shall come, Greeting:

This Is To Certify that the annexed is a true copy from the records of this office of the File Wrapper and Contents in the matter of the

Letters Patent of
Cranford P. Walker,
Number 2,156,519, Granted May 2, 1939,
Improvement in Means for Measuring the Location of Obstructions in Wells.

In Testimony Whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this seventh day of November, in the year of our Lord one thousand nine hundred and forty-one and of the Independence of the United States of America the one hundred and sixty-sixth.

(Seal) CONWAY P. COE
Commissioner of Patents.

Attest:

D. E. WILSON
Chief of Division.

1416

NUMBER 162699

PATENT No. 2156519

DIV. 42 5

PATENTED FILE 1937

RETURN TO RECORD ROOM

DATED MAY -2 1939

(EX'R'S BOOK)

Name CRANFORD P. WALKER

of SAN MARINO

State of CALIFORNIA

Invention METHOD AND MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Division of App., No. , filed , 19

ORIGINAL		RENEWED
APPLICATION FILED COMPLETE	SEPT 7, 1937	
PARTS OF APPLICATION FILED: Petition, Specification, Oath, First Fee $30, 2 sheets Drawings,	SEPT 7, 1937	
17 EXTRA CLAIMS $17	SEPT 7, 1937	
Examined and passed for Issue	Mar. 21, 1939	Reexam'd and passed for Issue , 193
R. W. Robinson Exr. Div. 5		Exr. Div.
Notice of Allowance	Mar. 21, 1939 By Commissioner.	Notice of Allowance , 193 By Commissioner.
Final Fee $3E	Apr. 3, 1939	Final Fee , 193

Attorney HAROLD W. MATTINGLY 924 PACIFIC FINANCE BLDG 621 S. HOPE ST LOS ANGELES CALIF

Associate Attorney

No. of Claims Allowed 17 Print Claims 7 + 13 in O.G. Class 181-0.5

Title as allowed Means For Measuring the Location of obstructions in Wells

Defendant's Exhibit T—(Continued)

Sep—7-37 43334 K—Check—30.00.
Sep—7-37 43334 K—Check—17.00.
Mail Division Sep 7 1937 U. S. Patent Office.

Harold W. Mattingly
Attorney at Law
Patent and Trademark Causes
924 Pacific Finance Building
621 South Hope Street
Los Angeles, California
MAdison 1137

1/85

September 2, 1937.

Commissioner of Patents,
Washington, D. C.

Sir:

Attached is application for Letters Patent of the United States executed August 31, 1937 by Cranford P. Walker; also attached is my check No. 201 in the amount of $47.00 to cover the Government filing fee (37 claims).

Respectfully,
HAROLD W. MATTINGLY

MM
Encls.

Defendant's Exhibit T—(Continued)
Mail Division Sep-7 1937 U. S. Patent Office.

PETITION

Received Sep 16 1937.
Division 5, Paper No. .....

To the Commissioner of Patents:

Your petitioner, Cranford P. Walker, a citizen of the United States, residing at San Marino, in the County of Los Angeles, and the State of California, whose post office address is 2824 Carlaris Road, San Marino, California, prays that Letters Patent may be granted to him for the ~~Method and~~ Means for Measuring the Location of Obstructions in Wells set forth in the annexed specification, and he hereby appoints

Harold W. Mattingly
924 Pacific Finance Building
621 South Hope Street
Los Angeles, California
(Registry No. 12,385)

his attorney, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.

(Sign here first name in full)

CRANFORD P. WALKER

Defendant's Exhibit T—(Continued)

SPECIFICATION

To All Whom It May Concern:

Be It Known, That I, Cranford P. Walker, a citizen of the United States, residing at San Marino, in the County of Los Angeles, and State of California have invented certain new and useful improvements in ~~Method and~~ Means for Measuring the Location of Obstructions in Wells of which the following is a specification:

My invention relates to ~~a method of~~ devices for measuring the location of obstructions in deep wells, such as oil wells, and has particular reference to ~~methods and~~ apparatus for determining the location below the ground surface of the liquid level in the well or the location of tools, pipe sections, couplings or other devices which constrict the well bore.

During the active life of an oil well it is desirable from time to time to determine the location of the fluid level within the well for the purpose of determining the type of pumping apparatus most desirable to be used, determining the rate of flow of oil into the well, and for making other determinations desirable in the most efficient operation of the well.

Prior methods of determining the location of the fluid level or the location of other obstructions in the well have been generally of two types, one in which measuring apparatus has been lowered from the ground surface to determine by the length of cable or line extended into the well the depth or location

Defendant's Exhibit T—(Continued)

of the fluid or other obstructions encountered by the instrument as it is lowered. Among devices to be lowered into the well is also included a pressure recorder which may be lowered into the well on a wire, the length of which is metered to determine the static pressure in the well at different levels, a variation of which includes a pressure recorder with a clock driven chart lowered on the bottom of the pump to obtain a record of the operating pressures or levels of the fluid. A further variation is that of lowering a bailer upon a rope and either measuring the wetted surface of the rope or repeatedly lowering the bailer until it brings up fluid, measuring the length of the line upon such occurrence. The other method is that of producing sound waves in the well and noting the elapsed time between the introduction of the sound and its return as an echo from the surface of the fluid or other obstruction encountered.

Neither of these methods is satisfactory, the first having the disadvantage of requiring the removal of oil flow tubing, sucker rods and other apparatus normally disposed in the well prior to the time the instrument is inserted in and lowered into the well, requiring a considerable length of time both for the removal of such apparatus, the reinsertion of the apparatus, and the making of the actual measurement. The other method is unsatisfactory primarily because of the relatively low intensity or energy which can be employed in the sound wave so that the echo received back is of such low energy as to prevent its accurate detection and, further, little or no

Defendant's Exhibit T—(Continued)

distinction is made by reason of such low energy between various types of obstructions encountered by sound wave.

A third method, namely, that of introducing a shock of relatively high intensity into the well, creating thereby a pressure wave which travels through the well, and measuring the elapsed time between the introduction thereof and the echo thereof, to give an indication of the depth of the fluid level and other obstructions, has been introduced, one form being that of creating an explosion in the well, another form being illustrated and described in United States Letters Patent No. 2,047,974, issued to Harold J. Wyatt and Paul E. Lehr on July 21, 1936. This latter method has the desirable characteristic of permitting the employment of relatively high intensity in the wave or impulse produced in the well and it is an object of my invention to improve upon the method disclosed in that patent and to eliminate or materially reduce factors of error encountered in the employment of that method.

Another object of my invention is to provide a method and apparatus for measuring the location of fluid level or other obstructions in well bores, in which the intensity of the pressure impulse introduced into the well may be varied to compensate for well depth and the character of the gaseous media through which the wave must travel to produce an echo of sufficient intensity to permit the same to be readily detected and translated.

Defendant's Exhibit T—(Continued)

~~Another object of my invention is to provide a~~ method and apparatus as set forth in ~~the~~ preceding paragraph wherein the pressure impulse may be so varied as to allow ~~the~~ detection and the separate determination of the location of a plurality of ob~~structions which may be encountered in the well~~.

Another object of my invention is to provide a device ~~method~~ for the measurement of the location of fluid level or other obstructions in a well bore in which the pressure impulse introduced into the well produces an indication both of the fluid level and of the location of other obstructions in the well bore.

Another object of my invention is to provide an ~~a method and~~ apparatus of the character set forth in the preceding paragraph wherein the same pressure impulse introduced into the well to measure the fluid level or the location of other obstructions is employed to determine the velocity of the wave in the particular media encountered in the well.

Another object of my invention is to provide an ~~a method and~~ apparatus as set forth in the preceding paragraph wherein, knowing the location of one or more obstructions, tools or other devices in the well bore, the velocity of the wave within the well bore may be accurately determined from echoes produced thereby and enabling an operator to determine the unknown location of the fluid level by the mere measure of the elapsed time between the introduction of the impulse into the well and the recep-

Defendant's Exhibit T—(Continued)

tion of a distinguishable echo from the fluid level, without necessitating introduction of corrective factors or other separate measurement of and determination of the character of the media in the well.

Another object of my invention is to provide an ~~a method and~~ apparatus for determining the location of fluid levels in well bores in which the location of and the number of tubing sections in the well may be determined by the same pressure wave created to measure the depth or the location of the fluid level.

~~Another object of my invention is to provide a~~ method as set forth in which when the location of none of the obstructions, tools or other devices in the well is known, a measurement and determination of the character of the media in the well may be made to accurately determine the velocity of the wave in ~~the particular well under consideration.~~

Other objects of my invention will be apparent from a study of the following specifications, read in connection with the accompanying drawings, wherein

Fig. 1 is a diagrammatic view illustrating a typical well cross section and the location and character of the apparatus required for determining the fluid level or location of other obstructions in the well in accordance with my method;

Fig. 2 is a diagrammatic view illustrating the type of record or indication which may be made with my method in its simplest application;

Defendant's Exhibit T—(Continued)

Fig. 3 is a diagrammatic view similar to Fig. 2 and illustrating the type of record or indication which may be made with my method but in which echoes produced by intermediate obstructions are not amplified;

Fig. 4 is a diagrammatic view similar to Figs. 2 and 3 and illustrating the type of record or indication which may be made with my method, including the aplification of echoes from intermediate obstructions; and

Fig. 5 is a vertical sectional view taken through one form of mechanical pressure responsive device which may be employed in my method.

The method disclosed in United States Letters Patent issued to Wyatt and Lehr, hereinbefore referred to, is briefly that of introducing into a well bore a pressure impulse, either positive or negative, which may have any desired frequency as by the introduction into the well of a quantity of gas of known pressure and volume, the introduction of this impulse into the well producing a wave which will travel down the well until it encounters the fluid surface in the well and then the wave will be reflected and will travel back up the well to the ground surface where the echo or return wave may be detected, the measurement of the elapsed time between the production of the impulse and the arrival at the ground surface of the echo constituting a measure of the location of the fluid level by the simple calculation of the elapsed time multiplied by the rate of travel or the velocity of the

Defendant's Exhibit T—(Continued)

wave in the well. In making such calculations, it is correctly assumed that the velocity of the wave will be the same as that of a sound wave. In air at normal temperatures and approximately sea level pressures, this rate would be 1100 feet per second but the gaseous content or media in the well is ordinarily not the same as air and correction must be made for the density, temperature or other characteristics of the particular media encountered in the well, it being well known that the higher the temperature or the lower the density of the gaseous media through which the impulse travels, the greater the velocity of the wave.

In employing the method as set forth in the said patent, an approximation of the fluid level may be readily determined and this approximation or measurement may be determined in a relatively short length of time, without requiring the removal or disturbance of any of the apparatus contained within the well bore. However, to determine the fluid level with considerable accuracy, the rate of travel of the wave in the particular media encountered in any particular well must be known or must be determined since the density, temperature and character of the gaseous media in wells varies in each different oil field and in each individual well. I provide means for readily determining at any particular well the velocity of the wave in that particular well, which may be arrived at as follows:

Defendant's Exhibit T—(Continued)

In Fig. 1 I have illustrated a typical oil well comprising the earth bore 1, usually lined with casing 2 or pipe of relatively large diameter, extending from the ground surface at 3 to the oil bearing sands at 4 where the casing is either perforated or is provided with a perforated liner through which the oil from the sands may enter to the interior of the casing. The casing is, of course, constructed of a plurality of lengths of pipe secured together by couplings or collars in any well known manner. A second pipe or string of pipes extend down through the casing 2, this string of pipe being known as the oil flow tubing, indicated at 5, extending from the ground surface down to a position disposed below the level of the fluid in the well, which is indicated at 6, the lower end of the tubing string 5 having a pump 7 of any desired character located therein. Such pumps are usually operated by means of a string of sucker rods 8 which extend upwardly through the tubing string 5.

It is the common practice to employ in the tubing string 5 a tubing catcher 9 which may be of any of the well known constructions, the tubing catcher being usually located a relatively short distance above the level of the fluid in the well so that should the tubing string break the tubing catcher 9 will grip the casing and prevent complete destruction of the tubing string. One or more of the tubing catchers 9 may be distributed throughout the length of the tubing string 5.

Defendant's Exhibit T—(Continued)

The tubing string 5 is constructed of a plurality of lengths of pipe coupled together by means of collars 10, which collars are usually of somewhat larger outside diameter than the outside diameter of the tubing from which the oil flow tubing is made.

Hence it will be noted that in the ordinary oil well there are a plurality of obstructions, each of which is capable of receiving and reflecting a sound wave or pressure wave passing down through the well, these obstructions including the fluid surface 6, the tubing catcher 9 and each of the collars 10 of the tubing string.

In most wells the length of the tubing string between the ground surface 3 and the pump 4 is known, that is, records are usually kept showing the length of each tubing string section and the number of such sections located within any given well. Particularly, records are usually kept as to the location along the tubing string of the catcher 9 so that by referring to these records an absolute calculation or determination of the distance between the ground surface and the tubing catcher or liner top is known. Hence to determine the location of the fluid level 6, it is only necessary to produce in the well a pressure impulse which will create the low frequency wave, and then translate the echoes received from the well in terms of echo impulses received from the tubing catcher or liner top and from the liquid surface. By comparing the time lapse between the production of the pressure impulse and the receipt of the echo from the tubing

Defendant's Exhibit T—(Continued)

catcher with the time lapse between the creation of the pressure impulse and the receipt of the echo from the fluid surface, a positive and accurate measurement of the location of the fluid level may be obtained. That is, if the known location of the tubing catcher is 5000 feet below the fluid surface and it is desired to know the height of the fluid in the well, all that is necessary is to produce a pressure impulse, note or record the echo from the tubing catcher, and note or record the echo received from the fluid surface. The time lapse between the creation of the pressure impulse and the receipt of the echo from the tubing catcher denotes the velocity of the pressure wave in the particular media encountered in that particular well so that by measuring the additional elapsed time between the receipt of the echo from the tubing catcher and the receipt of the echo from the fluid surface, an accurate measurement may be obtained and no compensation need be made for possible errors due to different velocities of waves in different media because the mean velocity of the wave from the ground surface to the tubing catcher and return is exactly the same as the mean velocity of the wave from the ground surface to the fluid surface and return.

The only item which must be provided for is that of producing a pressure wave echo of such magnitude and of such character that the echo from the tubing catcher can be distinguished from the echo received from the fluid surface.

Defendant's Exhibit T—(Continued)

As illustrated in Fig 1, this distinction may be readily made by providing a suitable source of fluid pressure indicated at 11 which may be a tank, compressor or other source of fluid pressure at any desired value. It follows, of course, that the pressure impulse which must be produced in the well must be at a greater pressure than the pressure of gases in the well so that the pressure source 11 must be capable of delivering a pressure impulse having a considerable differential over the static pressure of gases in the well or flowing therefrom. For example, if the well gases at the surface of the well are at a pressure of 500 pounds per square inch, the source of fluid pressure 11 must be capable of delivering, say, 600 pounds per square inch or more in order to create a pressure impulse of, for example, 100 pounds pressure differential.

The pressure source 11 is illustrated as being coupled to a pressure chamber 12, one end of which is connected as by means of tube 13 and valve 14 to the pressure source 11, while the opposite end of the pressure chamber 12 is connected by means of a nipple 15, a quick opening valve 16 and a nipple 17 to a length of pipe 18 which is in turn coupled as indicated at 19 to the well casing 2. The pressure chamber 12 is preferably provided with a suitable indicating pressure gage 20 by which the pressure within the pressure chamber 12 may be readily measured. Thus for the production of the pressure wave all that is necessary

Defendant's Exhibit T—(Continued)

is to close valve 16, open valve 14 and allow pressure to be built up in the pressure chamber 12 to the desired pressure value, say, 600 pounds per square inch. Then the valve 14 is closed and valve 16 opened, allowing an impulse of 600 pounds per square inch to be injected into the well casing (the static pressure in which is, for exampe, 500 pounds per square inch.)

(∧F¹) ~~The pipe 18 is illustrated as being coupled~~ through a valve 21 to a diaphragm chamber 22, permitting a flexible diaphragm 23 to be placed into communication with the casing 2 whenever the valve 21 is opened. To control the sensitivity of response of the diaphragm 23 and in order to prevent undue distortion of the diaphragm 23 by the static pressure in the well and to avoid damage which would result therefrom, I prefer to allow the static pressure in the well casing 2 and pipe 18 to be equalized on both sides of the diaphragm 23 as by providing a by-pass 24 providing a restricted passage through which gas pressure in the chamber 22 on one side of the diaphragm may pass to the opposite side of the diaphragm, the filter 25 being interposed in the by-pass if desired to dry out the gas and prevent undue corrosion of the more delicate parts of the device contained in the diaphragm chamber 22. Attached to the diaphragm 23 is a mirror 26, preferably connected as shown in Fig. 5 upon a link 27, one end of which link is coupled by means of a rod 28 to the diaphragm 23. The opposite end of the link 27 is preferably connected

Defendant's Exhibit T—(Continued)

to one arm of a bellcrank lever 29, as indicated at 30. The bellcrank lever 29 is pivoted as at 31 to any desired portion of the metal comprising the diaphragm chamber 22, another arm of the bellcrank lever 29 extending as indicated at 32 to be engaged by an adjusting rod 33 so that by operating the adjusting rod 33 the fulcrum point 30 of the link 27 may be varied as desired to properly position chart the beam on a recording ~~charg~~.

In the front wall 34 of the diaphragm chamber 22 I mount a lens 35, through which light from a suitable light source 36 may pass into the chamber 22 to be reflected by the mirror 26, the reflected beam 37 passing back through the lens 35, as a ribbon beam which may be reflected or directed upon a ground glass screen 38 and upon a recording chart or strip of sensitized tape 39 to make a permanent record of the path described by the light beam 37. Suitable reflectors, such as indicated at 40, may be employed to direct the beam in any desired direction while a reflector 40a may be interposed in a portion of the ribbon beam 37 to direct a portion thereof upon the screen 38, suitable condenser lenses 40b and 40c being interposed ing the light beam 34 upon the recording tape 39, a the screen 38 and tape 39.

Thus as the pressure within the casing 2 is varied as by the pressure wave resulting from the pressure impulse created within the casing 1, the mirror 26 will be moved, the amplitude of its movement repre-

Defendant's Exhibit T—(Continued)

senting the amplitude of the pressure variation. As the echo of the pressure impulse from any obstruction within the well is received upon the diaphragm 23, the mirror 26 will be moved in accordance with the amplitude of the echo impulse and, will cause the echo impulses to be registered for observation, both by directing the light beam 37 upon the ground glass 38, where the amplitude of the echo may be visually observed and ~~while~~, by directin the light beam 34 upon the recording tape 39, a permanent record of the pressure wave which is created within the casing 2 may be made and this wave or chart will show peaks of varying amplitude, each of which peaks represents an echo from a particular obstruction within the well, either the tubing collars 10, the tubing catcher 9 or the fluid surface 6.

The sensitized strip 39 may be arranged to be driven at any desired speed by means of a variable speed motor 41 coupled to a suitable source of current 42 through a rheostat or other speed adjusting device 43 so that the tape or strip 39 may be driven at variable speeds.

By employing some device which will produce upon the record strip 39 a time lapse measurement, a direct comparison between the path described by the light beam and the lapse of time may be accomplished. I prefer to provide such mechanism including means for producing upon the strip 39 a series of dots or marks, each of which represents a

Defendant's Exhibit T—(Continued)

fraction of a second, the line of dots or marks extending substantially parallel to the general direction of the wave chart described by the light beam 37. This may be readily accomplished by providing a disc 44 having a plurality of openings 45 therein adapted to be rotated in the path of a secondary light beam 46 emanating from the light source 36. The light beam 46 passing through the openings of the disc 44 may be projected upon the same sensitized strip 39 to describe a series of marks thereon, one for each of the openings 45. One of the opens 45a is preferably larger than the remainder so that upon each revolution of the disc 44 a distinguishing mark will be produced. Thus by providing ten openings 45, a series of marks 48a may be produced upon the record strip 39 representing ten equal divisions. The tenth mark being produced by the large opening 45a is of greater length or of greater size or in some other manner distinct from the remaining nine marks. By providing the disc 44 with any suitable time mechanism such as a synchronous motor 47, the marks produced upon the charts will represent lapse of time; for example, each mark representing 1/10th of a second while the space between the distinct marks will represent lapses of one second each.

Due to the fact that the depth of wells varies considerably and, further, due to the fact that conditions of obstruction or constriction of the space between the well casing 2 and the tubing string 5

Defendant's Exhibit T—(Continued)

varies considerably in different wells, the same pressure differential cannot be used successfully in all wells and it is necessary to vary the pressure impulse through considerably wide limits, dependent upon the conditions encountered at a particular well. For this reason I prefer to direct a portion of the beam 37 upon the ground glass screen 38 so that by firing one charge of gas pressure into the well and observing the path described by the light beam, a determination of whether or not the correct pressure impulse is being used may be made. For example, one pressure impulse which is estimated to be correct for a given well may not produce a sufficient fluctuation in the echo waves received from the tubing catcher and the fluid surface, and a higher pressure or greater quantity of gas must be used in order to create the desired impulse. Thus by observing the effect of a succession of pressure impulses liberated into the well, the person making the survey will be able to determine which of the echoes rebounds from the tubing catcher and which of the echoes rebounds from the fluid surface.

The pressure wave velocity in different wells varying through wide limits, it is desirable to provide some regulation controlling the sensitivity of response of the diaphragm 23 to pressure variations and also to control the sensitivity of the diaphragm to distinguish between echoes from different obstructions in the well. In some surveys it may be desirable to render this diaphragm more

Defendant's Exhibit T—(Continued)

sensitive than in making surveys of other wells under other conditions, particularly for the purpose of allowing the amplitude of movement of the light beam in response to collar echoes to be substantially the same in the surveying of different wells, and I provide a ready means for varying the sensitivity of response of the diaphragm 23 by providing in the pressure chamber 22 two distinct chambers or compartments. One of these compartments or chambers 48 may be formed centrally of the diaphragm chamber 22 as by providing an annular division wall 49, the chamber 48 being disposed on the forward side of the diaphragm 23 and constituting a chamber of fixed volume. The second of these chambers 50 may be provided between the annular wall 49 and the exterior wall of the diaphragm chamber 22, the volume of this chamber being relatively great as compared with the volume of chamber 48. By providing an orifice 51 in the wall 49 intercommunicating chambers 48 and 50 and providing a valve 52 for regulating the effective size of this orifice, the effective volume of the chamber communicating with the forward face of the diaphragm 23 may be varied in small increments so that the diaphragm 23 may be so regulated as to respond with varying degrees of sensitivity.

The typical desired configuration of the path described by the light beam 37 is indicated in Fig. 2 wherein a represents the path described by the light beam as a result of the pressure wave created by

Defendant's Exhibit T—(Continued)

a discharge of gas from the chamber 12 into the well casing. From an inspection of the line a, it will be noted that this line is a relatively straight but somewhat wavy line, having distinct peaks at b, c and d. The peak b is that which will be produced by the deflection of the diaphragm 23 when the impulse of gas from the chamber 12 is liberated into the casing 2. At a predetermined time thereafter, dependent upon the velocity of the wave in the particular well, a peak c will be produced as a reflection from the tubing catcher 9, while at a predetermined time thereafter an additional peak or series of peaks will be produced at d as a reflection of the wave from the fluid surface.

Thus by observing the effects of a series of pressure impulses of different intensity or pressure, the operator may determine which impulse is most desirable to produce the distinctly recognizable and differentiatable peaks c and d, allowing him to differentiate between echo from the tubing catcher and the echo from the fluid surface. As hereinbefore stated, knowing the depth or location of the tubing catcher 9, the comparison of the elapsed time between the peaks b and c and the elapsed time between the peaks b and d, an accurate determination of the fluid level may be produced.

After the most desirable pressure impulse has been determined, the motor 41 may be set into action and a permanent record of the path described by the light beam may be made upon the sensitized film 39 with assurance that the various peaks b, c and

Defendant's Exhibit T—(Continued)

d will be readily distinguishable upon the diagram so produced.

As will be observed from an inspection of Fig. 2, the diagram on the strip 39 also shows the plurality of spaced dots or other means of indicating elapsed time, such series of dots being indicated at 48a.

Having made a diagram as indicated in Fig. 2, a direct measure and determination of the fluid depth may be achieved. Also it will be observed that by selecting impulses of the desired magnitude, reflections from other obstructions in the well may be noted and recorded, thus assisting in the location and determination of other restrictions as well as a measurement of the fluid level.

For example, each of the collars 10 of the tubing string will produce a distinct echo differentiatable from the echoes from other sources. This allows the accurate measurement of the fluid level in a well where, by reason of failure to keep records or loss of records, the location of the tubing catcher is not known or wherein the catcher is submerged or is omitted. For example, in some wells tubing has been drawn out and replaced by other tubing and no record has been made of the lengths of tubing drawn out or the lengths of each section drawn out or the lengths or number of tubing section employed to replace them so that to merely compare the time distance between the peaks b and c would not give a true indication of the velocity of the wave in the particular well. However, if it is reasonably assured that each of the tubing lengths is approximately the same, and the usual practice in oil wells

Defendant's Exhibit T—(Continued)

is to employ tubing lengths ^ in ~~of~~ a given well, all of which are the same, an indication of the number of tubing lengths located within any given well, multiplied by the average length of a tubing section, will give a true measure of the location of the tubing catcher or the location of the pump or other device which constitutes an obstruction in the well. Thus, for example, by selecting a desired pressure impulse, by comparison of a succession of pressure impulses and the waves produced thereby, upon the ground glass 38, a wave or line of the character indicated at a in Fig. 3 may be produced wherein, though a is still wavy, it is produced by a series of peaks e. By counting the number of these peaks, each of which represents a reflection back from a collar 10, the number of lengths of tubing between the peaks b, c and d may be determined.

However, in actual practice there are so many other possible disturbances in the well as to create peaks similar to e which are not readily distinguishable therefrom and I prefer to provide a means for tuning out other vibrations, harmonics or other disturbances so that the peaks e will accurately represent only reflections from the collars 10.

As will be understood, the introduction into a sound wave or multiplicity of sound waves of another wave tuned with one of the waves, produces a beat or amplification of certain of these waves

Defendant's Exhibit T—(Continued)

differing in frequency from the first wave will be damped out. By selecting the correct length for the pipe 18, that is, by selecting the correct distance between the casing 2 and the diaphragm 23, a tuned wave may be produced which will effect the movements of the diaphragm 23. Since it is desired to count the number of tubing collars, all that is necessary is to lengthen or shorten the pipe 18 until it is tuned to one of the harmonics of the impulses or echoes produced by the collars 10. From experience it has been found that selection of the pipe 18 of approximately one-third of the length of a section or joint of the tubing 5, a third harmonic is produced which beats with the impulses echoed from the tube collars 10 to produce magnified or amplified peaks e and permits the ready distinguishing of the impulses produced by the collars 10 from other impulses.

I prefer, however, to employ in the length of the pipe 18 an adjustable coupling 19 which allows the accurate lengthening or shortening of the pipe 18 until, by observing the path of the light beam upon the ground glass 38, a distinct pattern is made represented by the line a on Fig. 4, in which each of the intermediate peaks e is amplified as indicated in Fig. 4 so that it is readily recognizable.

The adjustment of the coupling 19 should be made until, with a given pressure impulse, a uniform deflection of the mirror 26, that is, a uniform amplitude of the peaks e, is achieved, and by observing

Defendant's Exhibit T—(Continued)

this upon the ground glass 38 the operator will note when the pipe 18 is of such length as to be "tuned" with the tubing lengths.

Thus, even though the location of the tubing catcher is not known, if the average length of tubing section is known, the production upon the strip 39 of a diagram such as shown in Fig. 4 allows the counting of each of the collars 10 and a clear understandable record is made of the length of tubing string between the impulses b, c and d, permitting the quick and accurate location and determination of the exact level of the fluid in the well.

Where the tubing lengths are not known and where the location of the tubing catcher is not known, or where the catcher and liner top are submerged, a quick and ready method of determining the velocity of the pressure wave through the particular gaseous medium encountered in a particular well may be made by employing an elongated tube or pipe 53 coupled as by means of a short pipe 54 to the pipe 18 and controlled by a valve 55 in such manner as to permit gas from the casing 1 to flow through the pipe or tube 53, thus providing in the pipe 53 an atmosphere corresponding to the atmosphere or gaseous medium in the casing 1. An open exhaust pipe 56 leads from the opposite end of pipe 53 open to the atmosphere or connected to a gas flow line so that the pressure within the pipe or tube 53 will remain substantially constant as of the value of the gas in the casing 1. Near one end of the tube 53, a diaphragm 57 may be provided

Defendant's Exhibit T—(Continued)

and arranged to be vibrated at any desired frequency as by coupling the diaphragm 57 by a pipe 58 open to the atmosphere at 58a, to a source of fluid pressure, such as compressed air, indicated at 59. A rotary valve 60 is interposed in the pipe 58 and arranged to be driven by means of a variable speed motor 61 regulated as to speed by means of a variable speed motor 61 regulated as to speed by means of a suitable rheostat or other controlling device 62 so that by rotating the motor 61 at any speed a series of pressure impulses will be created in the pipe 58, and will beat upon diaphragm 57 to create a pressure wave in the tube or pipe 53 of known frequency, the frequency being variable by varying the speed of motor 61.

At the opposite end of the pipe 53 I couple a pressure responsive device which may be constructed in the same manner as the diaphragm chamber 22 and diaphragm 23 hereinbefore described. This pressure responsive device is illustrated at 63 coupled directly to the end of the pipe 53, the diaphragm 64 of which receives the impulses transmitted through the pipe 53 to vibrate in response thereto and to move a mirror 65 in the same manner as was described with reference to the mirror 26. The mirror 65 reflects a light beam from a suitable source 66 upon a polygon of mirrors 67 revolved by means of an adjustable speed motor 67a at a speed synchronous with the speed of the motor 61 so that the amplitude and uniformity of

Defendant's Exhibit T—(Continued)

the vibrations of the diaphragm 64 may be visibly observed.

As is well known in the art, each gaseous medium, variable as to density, temperature, etc., is resonant to pressure waves or sound waves of predetermined frequency. Thus by varying the speed of operation of the motor 61 until the pressure impulse created by the diaphragm 57 makes one round ∧ ~~stip~~ trip (or multiple thereof) to the diaphragm 64 and back to the diaphragm 57 in time to just synchronize with the next impulse created by the diaphragm 57, the pattern described by the beam of light on the mirrors 67 will show uniform amplitude, and noting the frequency of the impulses produced upon the diaphragm 57 (that is, noting the speed of the motor 61) the velocity of the sound through this particular gaseous medium may be readily determined by comparing this frequency with the frequency at which resonance is achieved at the pipe 53 with air in it.

It will therefore be observed that I have provided a method of determining the location of obstructions in wells and accurately locating and measuring the fluid level in a well without the necessity of removing any of the apparatus from the well, the entire measurement and determination being accomplished in a relatively short time.

It will be understood by those skilled in the art that the creation of pressure impulses within the well may be accomplished by decreasing the pres-

Defendant's Exhibit T—(Continued)

sure in the well instead of admitting a charge of gas from the pressure tube 12 into the well. For example, if the pressure in the well is relatively high, the valve 14 in the pressure chamber may be closed and the valve 16 opened, allowing the pressure in the well to build up within the impulse chamber 12. Then by operating valve 14, allowing the pressure within the chamber 12 to rapidly discharge, a pressure impulse may be created within the well which acts in the same manner as hereinbefore described for the introduction of pressure from the tank or other source 11.

It will also be understood that if desired special constrictions may be placed in the well for future measurements of the fluid level therein to take the place of the tubing catcher 9. Such constrictions could comprise a closed cylinder of pipe surrounding and attached to one of the tubing sections when the tubing is run into the well and by noting and recording the location of such constriction, the future measurements of the fluid level by my pressure impulse method can be readily determined, employing the reflection of the wave from the restricting member in place of the reflection from a tubing catcher 9 or other restriction in the well.

While I have shown and described the preferred embodiment of my invention, I do not desire to be limited to any of the details of construction shown

Defendant's Exhibit T—(Continued)

or described herein, except as defined in the appended claims.

I Claim:

~~1. The method of determining the location of~~ obstructions in wells which consists in creating a pressure impulse in the well, the amplitude of which impulse is variably selected dependent upon the depth of the well and the resistance to wave transmission in the well, to cause an echo thereof from the obstruction to arrive at some predetermined point with sufficient energy to be readily detected and translated, and measuring the lapse of time between the creation of said impulse and the arrival of the echo at said pre-determined point.

2. The method of determining the location of obstructions in wells which consists in creating in the well a pressure impulse the amplitude of which is selected proportional to the depth of the well and inversely proportional to the unrestricted cross sectional area of the well to cause an echo thereof from the obstruction to arrive at the ground surface with sufficient energy to be readily detected and translated, and measuring the lapse of time between the creation of the impulse and the arrival of the echo at a predetermined point.

3. The method of determining the location of obstructions in wells which consists in creating in the well a pressure impulse the amplitude of which is selected proportional to the depth of the well, ~~proportional to the gas pressure in the well and in~~

Defendant's Exhibit T—(Continued)

versely proportional to the unrestricted cross sectional area of the well to cause an echo thereof from the obstruction to arrive at the ground surface with sufficient energy to be readily detected and translated, and measuring the lapse of time between the creation of the impulse and the arrival of the echo at a predetermined point.

4. The method of measuring the location of obstructions in wells having a casing and oil flow tubing therein, which consists in creating within the casing a pressure impulse the amplitude of which is proportional to the depth of the well and inversely proportional to the annular space between the tubing and the casing to cause an echo thereof from the obstruction to arrive at the ground surface with sufficient energy to be readily detected and translated, and measuring the lapse of time between the production of the impulse and the arrival of the echo at the ground surface.

5. The method of determining the location of obstructions in wells, which consists of creating in the well a series of pressure impulses, each of different amplitude, until the echoes thereof from different obstructions in the well are readily distinguishable from each other, and then measuring the lapsed time between the creation of the impulse and the arrival of each of the distinguishable echoes at a predetermined point relative to the well.

6. The method of determining the location of obstructions in wells, which consists in creating in the well a series of pressure impulses, each of dif-

Defendant's Exhibit T—(Continued)

ferent amplitude, until the echoes thereof from different obstructions in the well are readily distinguishable from each other, and then measuring the lapsed time between the creation of the impulse and the arrival of each of the distinguishable echoes at the ground surface.

7. The method of determining the unknown location of an obstruction in a well having another obstruction at a known location, which consists in creating in the well a pressure impulse, measuring the lapse of time between the creation of the impulse and the arrival at a predetermined point of the echo from the known obstruction, and measuring the lapse of time between the creation of the impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

8. The method of determining the unknown location of an obstruction in a well containing a gaseous medium and having another obstruction at a known location therein, which consists in measuring the velocity of pressure waves through the well under measurement, creating a pressure impulse in the well and noting the lapse of time between the creation of the impulse and the arrival at a predetermined point in the well of the echo from the unknown obstruction.

9. The method of determining the unknown location of an obstruction in a well containing a gaseous medium and having an obstruction at a known location therein, which consists in creating a pressure impulse in the well, noting the elapsed

Defendant's Exhibit T—(Continued)

time between the creation of the impulse and the arrival at a predetermined point of the echo from the known obstruction to determine the velocity of the pressure wave through the well under measurement, and noting the lapse of time between the creation of the impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

10. The method of determining the unknown location of an obstruction in a well containing a gaseous medium and having an obstruction at a known location therein, which consists in creating a pressure impulse in the well at the ground surface, noting the lapse of time between the creation of the impulse and the arrival at the ground surface of an echo from the known obstruction to thereby determine the velocity of the pressure wave through the particular well under measurement, and noting the lapse of time between the creation of the pressure impulse and the arrival at the ground surface of the echo from the unknown obstruction.

11. The method of determining the unknown location of an obstruction in a well having a casing, tubing and tubing catcher or liner top therein, which consists in the creation at the ground surface of a pressure impulse within the casing, noting the lapse of time between the creation of the pressure impulse and the arrival at the ground surface of an echo from the tubing catcher or liner top whereby the velocity of pressure waves through

Defendant's Exhibit T—(Continued)

the particular well under measurement may be determined, and noting the lapse of time between the creation of the impulse and the arrival at the ground surface of the echo from the unknown obstruction, the location of the unknown obstruction calculated from the lapsed time between the creation of the pressure impulse and the arrival of the echo from the unknown obstruction.

12. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating a pressure impulse in the well, noting the echoes thereof from portions of the tubing string to determine the velocity of the pressure wave through the particular well under measurement, and noting the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo from the unknown obstruction.

13. The method of accurately determining the unknown location of an obstruction in a well having a string of tubing therein constructed of a plurality of lengths of tubing, each of approximately the same length, which consists in creating a pressure impulse in the well, noting the frequency of the echoes from the couplings of the tubing sections to determine the velocity of the pressure wave in the particular well under measurement, and noting the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo from the unknown obstruction.

Defendant's Exhibit T—(Continued)

14. The method of determining the unknown location of an obstruction in a well, which consists in locating another obstruction in the well at a known depth in the well, creating a pressure impulse in the well, noting the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo thereof from the obstruction of known location, and noting the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

15. The method of determining the location of an obstruction in a well containing a gaseous medium, which consists in passing the gaseous medium from the well through a pipe of predetermined length, creating in said pipe pressure impulses to produce therein a pressure wave, varying the frequency of said impulses until resonance of the wave in said pipe and in said gaseous medium is achieved, comparing said frequency with the resonant frequency of said pipe when filled with air to determine the velocity of pressure waves through the particular well under measurement, and then creating a pressure impulse in said well, and noting the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo thereof from the unknown obstruction.

16. The method of determining the location of an obstruction in a well containing a gaseous me-

Defendant's Exhibit T—(Continued)

sections interconnected by coupling collars
dium and having located therein a string of tubing ∧ ~~located therein,~~ which consists in coupling a pressure responsive device to the well, creating a pres-
adjusting the length of
sure impulse in the well, ∧ ~~lengthening or shortening~~ the coupling between the well and the pressure
pressure responsive device
responsive device until the ∧ ~~coupling~~ is tuned to one of the harmonics of the echoes of the pressure
collars
impulse from successive ∧ ~~couplings~~ in the tubing string, noting the frequency of the echoes from the collars of the tubing string to determine the velocity of pressure waves through the particular well under measurement, and measuring the lapsed time between the creation of a pressure impulse in the well and the arrival at a predetermined point of the echo from the obstruction.

17. The method of determining the location of an obstruction in a well, which consists in introducing a pressure impulse into the well, coupling a pressure responsive device to the well, and visually indicating the movements of said pressure responsive device under the influence of echoes of the pressure impulse.

18. The method of determining the location of an obstruction in a well, which consists in introducing a pressure impulse into the well, coupling a pressure responsive device to the well, visually indicating the movements of said pressure responsive device under the influence of echoes of the pressure impulse, and

Defendant's Exhibit T—(Continued)

drawing a graph of said movements related to time lapse between successive movements.

19. The method of determining the location of an obstruction in a well, which consists in creating a series of pressure impulses in the well, coupling a pressure responsive device to the well, visually indicating the movements of the pressure responsive device under the influence of echoes received from obstructions in the well, varying the amplitude of successive pressure impulses until the indication of the echo from the obstruction to be measured is clearly visually distinguishable from other pressure vibrations, and measuring the lapse of time between the creation of the impulse of the selected magnitude and the response of the pressure responsive device to the echo from said obstruction.

20. In an apparatus for determining the location of an obstruction in a well, means for creating pressure impulses in the well of variable amplitude, and means for measuring the lapse of time between the creation of any of the impulses and the arrival at a predetermined point of the echo of said impulse from said obstruction.

21. In an apparatus for determining the location of an obstruction in a well, means for creating pressure impulses in the well of variable amplitude, a pressure responsive device movable in response to pressure impulses applied thereto, the amplitude of the movement varying in accordance with the amplitude of the impulse received, means for visually observing the movements of said pressure responsive

Defendant's Exhibit T—(Continued)

device, and means for measuring the lapse of time between the creation of any of the impulses and the arrival at a predetermined point of the echo of said impulse.

22. In an apparatus for determining the location of an obstruction in a well, means for creating pressure impulses in the well of variable amplitude, a pressure responsive device movable in response to pressure impulses applied thereto, the amplitude of the movement varying in accordance with the amplitude of the impulse received, light reflecting means associated with said pressure responsive device, means for directing a light beam upon said reflecting means, and means for receiving the reflected beam including both a screen for visually observing the movement of the reflected light beam, and a light sensitive recording means for making a permanent record of the movement of said reflected beam.

23. In an apparatus for determining the location of an obstruction in a well, means for creating a pressure impulse in the well, a pressure responsive device movable in response to pressure impulses applied thereto, the amplitude of the movement varying in accordance with the amplitude of the impulse received, light reflecting means associated with said pressure responsive device, means for directing a light beam upon said reflecting means, and means for receiving the reflected beam including both a screen for visually observing the movement of the ~~reflected light beam, and a light sensitive recording~~

Defendant's Exhibit T—(Continued)

~~mean for making a permanent record of the movement of said reflected beam.~~

2 ~~24~~. In an apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure responsive device for receiving pressure impulses from the well, a pipe coupling said pressure responsive device to the well, adjusting the ~~length of~~ effective length of means for ∧ ~~lengthening or shortening~~ said pipe to pressure responsive device tune said ∧ ~~pipe~~ to one of the harmonics of echoes of said impulse received from the coupling collars of said tubing string, and means for measuring the frequency of said tubing collar echoes and for measuring the lapse of time between the creation of said impulse and the arrival at the pressure responsive device of the echo of said impulse from said obstruction.

3 ~~25~~. In an apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure responsive device for receiving pressure impulses from the well, a pipe coupling said pressure responsive device to the well, adjusting the ~~length of~~ effective length of means for ∧ ~~lengthening or shortening~~ said pipe to pressure responsive device tune said ∧ ~~pipe~~ to one of the harmonics of echoes of said impulse received from the coupling collars.

Defendant's Exhibit T—(Continued)

of said tubing string, and means associated with said pressure responsive device for measuring the frequency of said tubing collar echoes and for counting the same and for measuring the lapse of time between the creation of said impulse and the arrival at the pressure responsive device of the echo of said impulse from said obstruction.

4 ~~26~~. In an apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure responsive device for receiving pressure impulses from the well, a ^ ~~pipe~~ means intercoupling with ~~coupling~~ said pressure responsive device ^ ~~to~~ the well and having such effective length as to tune said pressure responsive device ^ ~~pipe~~ to one of the harmonics of echoes of said impulses received from the coupling collars of said tubing string, and means associated with said pressure responsive device for measuring the frequency of said tubing collar echoes and for couting the same and for measuring the lapse of time between the creation of said impulse and the arrival at the pressure responsive device of the echo of the impulse from said obstruction.

~~27. In an apparatus for determining the location of an obstruction in a well, means for creating a pressure impulse in the well, a pressure responsive device including diaphragm means, means coupling said diaphragm means to said well to allow the pres-~~

Defendant's Exhibit T—(Continued)

~~sure of said well to press upon said diaphragm~~ means whereby said diaphragm means will move in accordance with variation in pressure within said well, and means for measuring the lapse of time between the creation of said pressure impulse and the movement of said diaphragm means by the echo ~~of said impulse from said obstruction~~.

5 ~~28~~. In an apparatus for determinig the location of an obstruction in a well, means communicating with said well for creating a pressure impulse in the well, a pressure responsive device including diaphragm means, means coupling said diaphragm means to said well to allow the pressure of said well to press upon one face of said diaphragm means, means communicating between said coupling means and the opposite face of said diaphragm means for equalizing the static pressure on both sides of said diaphragm means whereby said diaphragm means will move in accordance with variation in pressure within said well, and means for measuring the lapse of time between the creation of said pressure impulse and the movement of said diaphragm means by the echo of said impulse from said obstruction.

6 ~~29~~. In an apparatus for determining the location of an obstruction in a well, means communicating with said well for creating a pressure impulse in the well, a pressure responsive device including diaphragm means, means coupling said diaphragm means to said well to allow the pressure of said well to press upon one face of said diaphragm means, means defining a restricted by-pass intercommuni-

Defendant's Exhibit T—(Continued)

cating the opposite face of said diaphragm means with said coupling means to equalize the static pressure on both faces of said diaphragm means whereby said diaphragm means will move in accordance with variation in pressure within said well, and means for measuring the lapse of time between the creation of said pressure impulse and the movement of said diaphragm means by the echo of said impulse from said obstruction.

7 ~~30~~. In a device for determining the location of an obstruction in a well, means communicating with said well for creating a pressure impulse in said well, means for receiving and translating echoes received from said obstruction including diaphragm means, coupling means intercommunicating one face of said diaphragm means with said well, means defining a pressure equalizing chamber on the opposite face of said diaphragm, means defining a second chamber of greater volume communicating with said first chamber, valve means for restricting communication between said two chambers to vary the effective volume of the chamber exposed to said opposite face of said diaphragm means to control the sensitivity of response of said diaphragm means to pressure variation in said well, and means for measuring the lapse of time between the creation of said impulse and the movement of said diaphragm by the echo of said impulse from said obstruction.

~~31. In a device for measuring pressure fluctuations, a pressure responsive device movable in response to pressure impulses applied thereto, the am-~~

Defendant's Exhibit T—(Continued)

plitude of the movement varying in accordance with the amplitude of the impulse received, light reflecting means associated with said pressure responsive device, means for directing a light beam upon said reflecting means, and means for receiving and translating the reflected beam.

32. In a device for measuring pressure fluctuations, a pressure responsive device movable in response to pressure impulses applied thereto, the amplitude of the movement varying in accordance with the amplitude of the impulse received, light reflecting means associated with said pressure responsive device, means for directing a light beam upon said reflecting means, and means for receiving and recording the path described by said light beam, said recording means including a movable tape, means for directing the light beam upon said tape, means for moving said tape past said light beam receiving means at a predetermined rate of speed, means for producing upon said tape a time lapse record extending substantially parallel to the record produced by said beam, said time record including markings denoting lapses of units of time and distinguishable markings denoting lapses of multiples of said units.

33. The method of determining the velocity of pressure waves in a given medium, which consists in passing said medium through an elongated tube, producing in said tube pressure waves of known frequency, varying said frequency until resonance of the pressure waves is achieved, and comparing the

Defendant's Exhibit T—(Continued)

resonance frequency with the resonance frequency in said tube in air.

34. In an apparatus for determining pressure wave velocity in a given medium, an elongated tube, means communicating with said tube for passing the said medium through said tube, means associated with said tube for creating pressure waves in said tube of known frequency, means associated with said pressure wave creating means for varying said frequency, and means communicating with said tube for determining when the frequency is such as to resonate in the medium in the tube.

35. In an apparatus for determining pressure wave velocity in a given medium, an elongated tube, means communicating with said tube for passing the said medium through said tube, means associated with said tube for creating pressure waves in said tube of known frequency, means associated with said pressure wave creating means for varying said frequency, and means communicating with said tube for observing pressure fluctuations in said tube to determine resonance of the waves in said medium.

36. In an apparatus for determining pressure wave velocity in a given medium, an elongated tube, means communicating with said tube for passing the said medium through said tube, means associated with said tube for creating pressure waves in said tube of known frequency, means associated with said pressure wave creating means for varying said frequency, diaphragm means communicating with said tube for movement under the influence of pressure

Defendant's Exhibit T—(Continued)

~~variations in said tube, a source of light, means~~ associated with said diaphragm for directing a light beam from said source upon a screen whereby observing the form and amplitude of movement of said light beam on said screen resonance of said frequency in said medium may be observed.

37. A method and means for measuring the location of obstructions in wells substantially as shown ~~and described.~~

In Testimony Whereof I affix my Signature
(Sign here first name in full)
CRANFORD P. WALKER.

OATH

State of California
County of Los Angeles—ss.

Cranford P. Walker, the above named petitioner, being duly sworn, deposes and says that he is a citizen of the United States, and resident of San Marino, California; that he verily believes himself to be the original, first and sole inventor or discoverer of the Method and Means for Measuring the Location of Obstructions in Wells described and claimed in the annexed specifications; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this applica-

Defendant's Exhibit T—(Continued)

tion; that said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months prior to this application; and that no application for patent on said invention has been filed by him or his legal representatives or assigns in any country foreign to the United States.

(Sign here first name in full)

CRANFORD P. WALKER

Subscribed and sworn to before me, this 31st day of August, 1937.

(Seal) MARJORIE McKAY

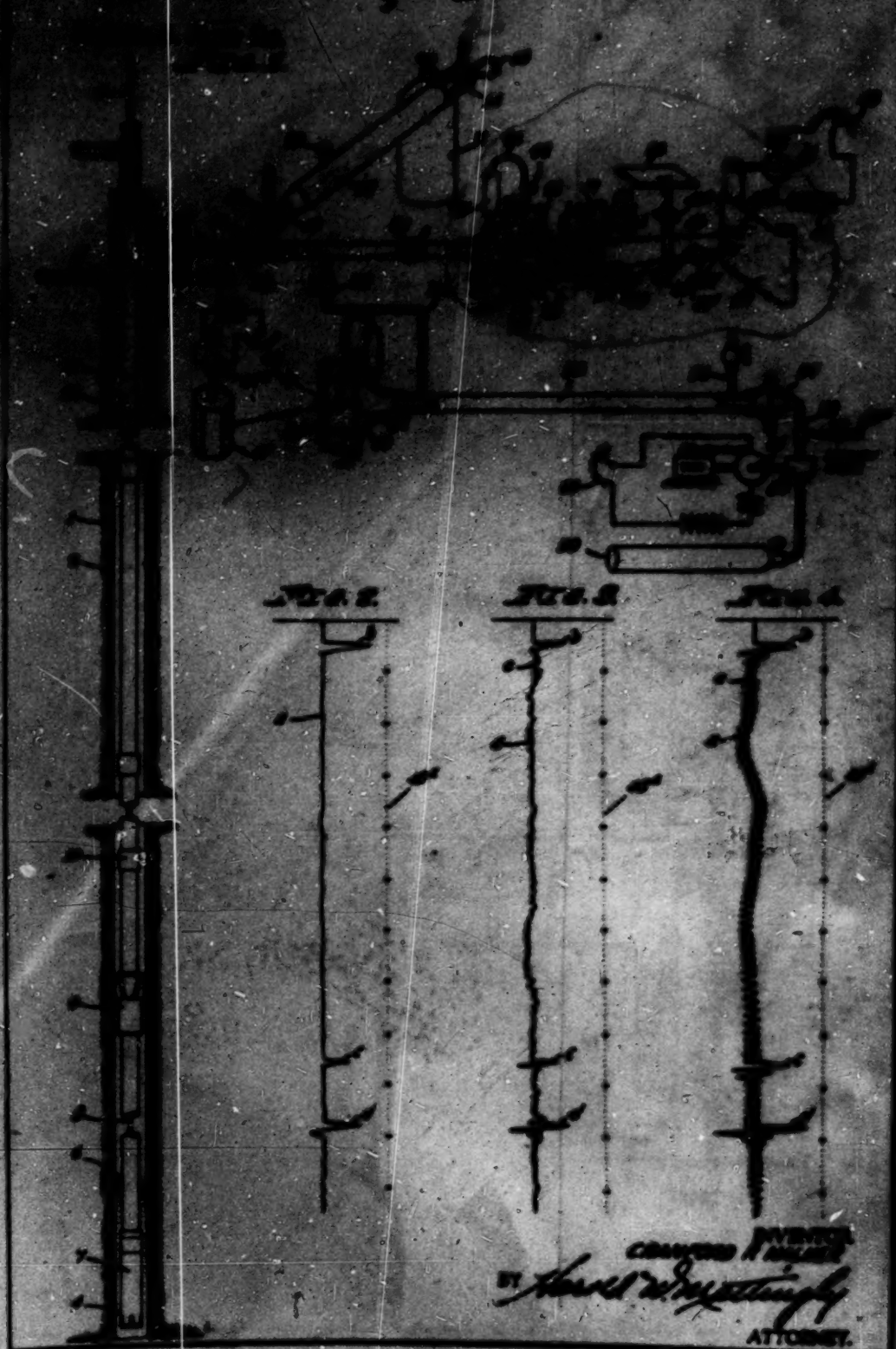
Notary Public in and for the said County and State

My Commission Expires July 14, 1941

162699

Print of drawing as originally filed.

5-19
5-2

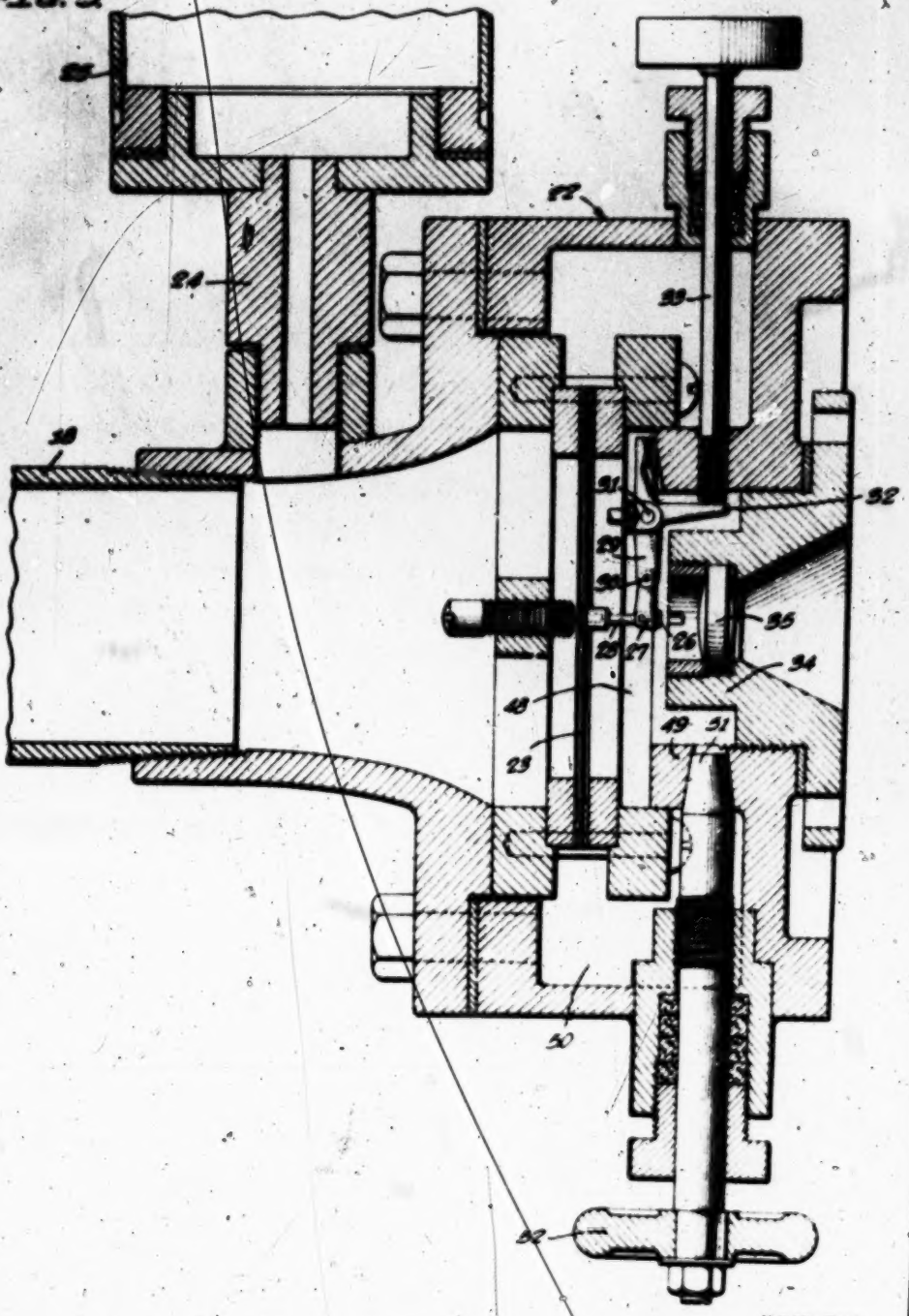


INVENTOR
CRAWFORD H. MILNER
BY Harold W. Mettingly
ATTORNEY.

162699 46 181-0.5

Print of drawing as originally filed.

FIG. 5.



INVENTOR
CRANFORD P. WALKER
BY Harold W. Mellingly
ATTORNEY

Defendant's Exhibit T—(Continued)

260

Div. 5 Room 3077.

Department of Commerce
United States Patent Office
Washington

Paper No. 3

All communications respecting this application should give the serial number, date of filing, and name of the applicant

Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name

CLJ/H

Oct. 25, 1937

Please find below a communication from the EXAMINER in charge of this application.

CONWAY P. COE
Commissioner of Patents.

Defendant's Exhibit T—(Continued)

Harold W. Mattingly
924 Pacific Finance Bldg.
621 S. Hope St.
Los Angeles, Calif.

Applicant: Cranford P. Walker
Ser. No. 162,699
Filed Sept. 7, 1937
For Method and Means for Measuring the Location of Obstructions in Wells

Mailed Oct 25 1937.

References made of record:

Batcheller	602,422	Apr. 19, 1898	181-0.5
Taylor	1,847,636	Mar. 1, 1932	274-5 x-r

Page 13, line 11, should not "charg" be chart?

Page 24, line 10, should not "stip" be trip?

Claims 1 to 13, 17 to 21 and 24 to 27 are rejected as being unpatentable over Batcheller, who shows it to be old to create an impulse in a well to travel down until an obstruction is reached, and to return as an echo to energize a recorder from which an indication may be had as to the depth of the obstruction below the surface.

Claims 14 to 16, 28 to 30 and 33 to 36 are deemed to be allowable.

Claims 22, 23, 31 and 32 are rejected as being unpatentable over Batcheller above cited, who shows a means of recording the pressure wave in a well, in view of Taylor, who shows a recording device for recording sound waves embodying the same struc-

Defendant's Exhibit T—(Continued)

ture as is utilized by applicant. No invention is seen to be required to substitute the recording device of Taylor for the recorder of Batcheller.

Claim 37 is rejected as not meeting the requirements of Section 4888, Revised Statutes.

C. W. ROBINSON,
Examiner.

Mail Division Apr 21 1938 U. S. Patent Office.
Received Apr 23 1938 Division 5, Paper No. 4
Amendment A.

In the United States Patent Office
Division 5 — Room 3077

Cranford P. Walker,
Method and Means for Measuring the Location of Obstructions in Wells,

Filed September 7, 1937,
Serial No. 162,699.

Los Angeles, California,
April 19, 1938.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

In response to the Office action of October 25, 1937, please amend the above identified application as follows:

Page 13, Line 11, change "charg" to read —chart—.

Page 24, Line 10, change "stip" to read —trip—.

Defendant's Exhibit T—(Continued)

Cancel Claims 17, 18, 27, 31, 32 and 37 and add the following claims:

A[1]

8 ~~38~~. In a device for measuring pressure waves in a fluid medium under static pressure, a diaphragm, a pressure-tight housing surrounding said diaphragm and having a window therein capable of passing light between the interior and exterior of the housing, said housing being divided by the diaphragm into two compartments, one on each side of the diaphragm, a medium entrance communicating with one compartment to directly expose one face of the diaphragm to the medium, a by-pass extending between the compartments to equalize the static pressure of the medium on opposite faces of the diaphragm, light-reflecting means associated with the diaphragm, means for directing a light beam upon said reflecting means to reflect the beam through said window, and means disposed exteriorly of said housing for receiving and translating the reflected beam.

9 —~~39~~. In a device for measuring pressure waves in a fluid medium under static pressure, a diaphragm, a pressure-tight housing surrounding said diaphragm and having a window therein capable of passing light between the interior and exterior of the housing, said housing being divided by the diaphragm into two compartments, one on each side of the diaphragm, a medium entrance communicating with one compartment to directly expose one face of

Defendant's Exhibit T—(Continued)

the diaphragm to the medium, a by-pass extending between the compartments to equalize the static pressure of the medium on opposite faces of the diaphragm, light-reflecting means associated with the diaphragm, means disposed exteriorly of the housing for directing a light beam through said window to strike said reflecting means and to be reflected thereby back through said window, and means disposed exteriorly of said housing for receiving and translating the reflected beam.—

REMARKS

Reconsideration of Claims 1 through 6 is respectfully requested. The Examiner rejected each of these claims as unpatentable over the patent to Batcheller. It is believed that in making this rejection of Claims 1 through 6 the Examiner has overlooked the important limitation in each of these claims to the effect that the amplitude of the impulse which is produced in the well is variable or variably selected in such manner as to produce a wave pattern in which various obstructions or restrictions in the well may be clearly distinguished from each other, as for example the tubing collars will produce a distinct wave pattern, the tubing catcher will produce a different wave pattern, the fluid level will produce a still different wave pattern, perforations in the casing or in the screen liner will produce a different pattern, the top of the screen liner will produce a different pattern, while other enlargements or constructions of the diameter of the well

Defendant's Exhibit T—(Continued)

casing or bore will produce such distinctive wave patterns that each of these may be detected upon the record and clearly recognized both as to their character and as to their location. This is possible to accomplish only if the proper amplitude or magnitude of pressure impulse is created in the well and the magnitude of the impulse must be capable of being changed, either increased or decreased until the wave pattern produced by echoes from the different obstructions are capable of being distinguished from each other.

The mere creation of a pressure impulse of arbitrarily selected magnitude, as is disclosed in Batcheller, may produce a result of obtaining a reflection from one obstruction in the well which can be detected and located thereby but only provided the impulse obtained by the shot is by remote chance and accident so coordinated with the gas pressures existing in the well and the depth of the obstruction from the ground surface that the echo can be received and detected at the surface. In other words, utilizing the method and apparatus disclosed in Batcheller leaves the results entirely up to chance.

Not until the applicant devised his method and apparatus for producing impulses of varying magnitude was it possible to measure, locate and distinguish various obstructions in the well by the sound or pressure wave method. Previous to his discovery that there was a direct relation between the magnitude of the impulse, the gas pressures in the well,

Defendant's Exhibit T—(Continued)

the amount of restriction or resistance to the passage of the impulse through the well and the depth of a particular obstruction or restriction sought to be measured, many attempts were made to use the pressure echo principle to locate and distinguish obstructions in wells with only indifferent and intermittent success. The reasons for the failure were not known and because of such failures the Batcheller method was not considered to be commercially practicable. It was only after the applicant discovered the relation between all of these factors and had determined that a pressure impulse which would produce results in one well would produce no useable results in another well that commercial applications of the pressure echo principle were made possible.

The use of pressure impulses of varying magnitude is an important improvement over anything which is disclosed in the Batcheller patent since it is the difference between success and failure. By employing the applicant's method of using an impulse of one magnitude, checking the results, then using the impulse of another magnitude and checking the results until the correct impulse is determined, and then making the measurement, the resultant graph will clearly and readily distinguish the location of the particular obstruction which may be readily and accurately determined and distinguished from any other obstructions that may exist in the well or by estimating the probable location of the unknown obstruction, estimating, measuring or computing the gas pressure and the known restrictions in the path

Defendant's Exhibit T—(Continued)

of the impulse and echo, an impulse of the correct magnitude may be selected with assurance of useful results.

Attached hereto is a copy of an actual graph made upon a well by the applicant's method as outlined in Claims 1 through 6. In testing this will several different impulses were tried and their effects were observed upon the screen 38 until the operator observed that each of the elements in the wave pattern was distinguishable from each other. Then another impulse of this same magnitude was used and the graph was made, in which can be readily distinguished each of the tubing collars between the points X and Y, the tubing catcher at a depth of 1850 feet, the liner top at a depth of 1930 feet, the location of perforations in the casing or liner below the liner top and the location of the fluid level at the point indicated at Z where the wave pattern tends to smooth out into a smooth curve. Such wave pattern with each of the obstructions clearly distinguishing from the others could not be produced by the Batcheller method but only by the applicant's method in which a series of impulses are used to determine which of them is the best or in which after suitable calculation a predetermined impulse is selected to produce the desired result.

It is therefore clear that the limitation of variably selecting the amplitude of the impulse as specified in Claims 1, 5 and 6, or initially selecting the amplitude of the impulse to conform with gas pressure, restrictions and depth of the well as specified in

Defendant's Exhibit T—(Continued)

Claims 2, 3 and 4, constitutes an improvement over the method disclosed in Batcheller, which improvement advances this art and is therefore patentable.

Reconsideration of Claims 7 through 12 is respectfully requested, each of these claims being directed to a method which includes steps not disclosed in Batcheller, namely, the method of determining the location of an unknown obstruction by comparing the lapse of time for the echo from the unknown obstruction to reach the ground surface with the lapse of time required for the echo from a known obstruction to reach the ground surface. Each of these claims is directed to the feature that the velocity of the echo will be different for every well and that one way in which to make an accurate determination of the location of an unknown obstruction is to first determine the velocity of the echo waves in the particular well under consideration by employing some obstruction at known depth to compare the lapse of time for the travel of the echo from the unknown obstruction. There is no teaching of this method or these steps in the Batcheller disclosure and in the absence of a reference showing these steps these claims must be allowed.

Reconsideration of Claim 13 is respectfully requested, this claim having to do with the comparison of the frequency of the echoes from the tubing collars as a means for determining the velocity of the pressure wave in a particular well and utilizing the velocity value so determined to determine the location of the unknown obstruction. Again there is no

Defendant's Exhibit T—(Continued)

such teaching in the Batcheller patent and this claim is clearly allowable over the Batcheller patent.

Reconstruction of Claim 19 is respectfully requested, this claim having to do with the method which consists in producing a series of pressure impulses in the well, varying the amplitude of the successive impulses, and observing the effects of the different impulses until the echoes from the unknown obstruction are clearly distinguishable from other vibrations which may be disregarded or echoes from other obstructions which are at known locations or observation of which is not necessary. Again the use of variable impulses is not shown in Batcheller nor is the observation of the effects of different impulses shown in Batcheller and this claim is clearly allowable over the reference.

Reconsideration of Claim 20 is respectfully requested for the same reasons as set forth with reference to Claims 1 through 6, this claim being directed to the apparatus for determining the location of an obstruction in a well which includes "means for creating pressure impulses in the well of variable amplitude" which is a feature not shown in the Batcheller patent and without which the Batcheller patent is either totally unsuccessful or produces such unreliable results as to render it substantially without utility. As set forth with reference to Claims 1 through 6, it is the applicant's ability to produce a series of impulses of variable magnitude which permits him to select the impulse of proper magnitude to obtain a resultant graph

Defendant's Exhibit T—(Continued)

in which the particular obstruction sought to be located may be clearly distinguished from other obstructions which are either known or the location of which is not particularly desired. Unless the Examiner can find a reference which shows that this important improvement step was known and which discloses mechanism by which this improvement can be obtained, this claim, like Claims 1 through 6, must be allowed.

Reconsideration of Claims 21, 22 and 23 is respectfully requested for the reason that each of these claims includes the means for producing the impulse of "variable magnitude" and also the means by which the effects of the different impulses may be visually observed so that an operator can create a succession of impulses of variable magnitude, visually observe their results until he knows that an impulse of the proper magnitude has been found, and then he may produce the graph or may otherwise measure the time lapse between the creation of the impulse and the return of the echo from a particular obstruction he seeks to determine. This is more than the mere shooting of a pistol into a well and watching a pressure indicator such as that shown in Batcheller; instead, it involves a step of the method and mechanism which permits the production of this step, neither of which is shown or suggested by Batcheller.

As expressed in Claim 21, this observance and selection of the correct impulse may be accomplished with any mechanism which will permit vis-

Defendant's Exhibit T—(Continued)

ual observation of the effects of the impulse while in Claims 22 and 23 this means for making the observation and selection is defined as a light beam means, which lends itself peculiarly by reason of the ease with which the various echoes may be distinguished from each other on the screen and the fidelity with which the light beam may follow the variations in the pressures resulting from the echoes. It would therefore require invention to adapt the Batcheller disclosure to produce the results set forth in these claims and Batcheller therefore fails as a basic reference for the reason that it fails to show the complete combination for producing the result, one essential element being missing, namely, the means for creating impulses of variable magnitude. Batcheller failing as a basic reference, it is then not proper for the Examiner to combine with the faulty Batcheller disclose a disclosure of a light beam translation mechanism to the structure of Batcheller and to hold that there would be no invention in such combination. Even though it were true that it would not require invention to substitute the Taylor translation mechanism for the mechanical mechanism of Batcheller (and applicant does not admit this) the combination of these references would still fail to meet the invention expressed in these claims.

Reconsideration of Claims 24 and 25 is respectfully requested, each of these claims defining an important feature of the applicant's device which is not found in Batcheller, namely, the ability to

Defendant's Exhibit T—(Continued)

tune the instrument to the echoes received from a succession of tubing collars to thereby permit the applicant to count the tubing collars by the echoes from the tubing collars. This is illustrated particularly in Fig. 4, showing the result of the tuning of the translation mechanism with one of the harmonics of the echoes from the tubing collars. With the graph shown in Fig 2 it would be impossible to count the tubing collars while tuning the translation device to the echoes or one of the harmonics of the echoes from the tubing collars produces a graph as shown in Fig. 4 in which the record of each of the tubing collars is clearly apparent and distinguishable from other echoes received from other obstructions. The Examiner's attention is called to the actual graph made by the applicant's method and apparatus in which it is seen that each of the tubing collar echoes may be clearly distinguished so that they may be counted for the purposes set forth on Pages 19 and 20 of the specification, and the ability to produce such a graph constitutes an important contribution by the applicant to this art. To merely fire a shot into a well and observe such echoes as may be reflected back in accordance with the Batcheller method and apparatus would not produce this result and hence each of these claims clearly defines patentable subject matter.

Reconsideration of Claim 26 is also respectfully requested for the same reasons as set forth with

Defendant's Exhibit T—(Continued)

reference to Claims 24 and 25. In Claim 26 the length of the coupling between the pressure responsive device and the well is selected such that it is tuned to the harmonics of the echoes from the tubing collars, the result being a new and valuable result impossible to obtain with the Batcheller method or device. The applicant has found that in many instances it is possible, knowing the length of the tubing collars, to previously select a length of pipe to couple the pressure responsive instrument to the well in such manner as to "pre-tune" the instrument to the harmonics of the tubing collar echoes and is clearly entitled to protection upon this feature as expressed in Claim 26.

Reconsideration of new Claims 38 and 39 which have been substituted for original Claims 31 and 32, each of these claims clearly and definitely bringing out the cooperation between the applicant's pressure responsive device and the light beam translation mechanism associated therewith, is respectfully requested. As will be readily appreciated by the Examiner, the diaphragm which is exposed to the well must be so enclosed that the effect of the static pressure in the well will be equalized on opposite sides of the diaphragm and in order to accomplish this result it is necessary that the diaphragm be enclosed within a pressure-tight housing. By reason of the necessity of enclosing the diaphragm, some means must be provided for exteriorly receiving and translating the motions of the

Defendant's Exhibit T—(Continued)

diaphragm which can be accomplished by providing a window in the housing and projecting a light beam through the window without interferring in any manner with the sensitivity of response of the diaphragm to the pressure waves sought to be translated. Thus the light beam translation device becomes an important element cooperating with a diaphragm pressure responsive device for the applicant's apparatus.

There is no enclosing of the diaphragm in the Batcheller patent. There is no equalizing of pressure on both sides of the diaphragm in the Batcheller patent. The Taylor patent does not contemplate any such problem as that presented to the applicant, nor does it disclose how the light beam translation means could be adapted to the applicant's purpose and to solve the applicant's problem, namely, that of transmitting and translating motions of an enclosed diaphragm to an exterior translation or receiving device. It would be impossible to produce the applicant's result by combining the Batcheller disclosure with the Taylor disclosure unless the important elements, namely, (a) the housing with its pressure equalizing means, and (b) the window through which the motions of the enclosed diaphragm can be observed and translated exteriorly of the housing, were added to the combined disclosures. It is the new combination of the elements shown in the Batcheller patent and the elements shown in the Taylor patent plus the

Defendant's Exhibit T—(Continued)

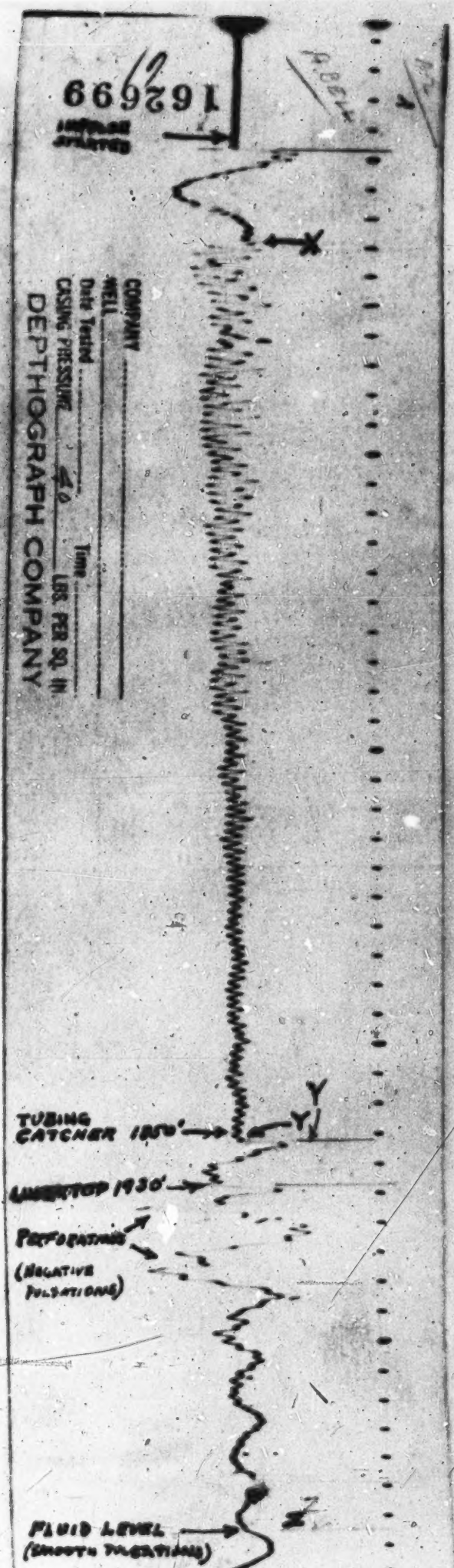
new elements found in neither of these prior patents which constitutes the applicant's patentable contribution, as expressed in Claims 38 and 39.

The remaining claims in this application stand allowed and it is believed that in view of the foregoing arguments all of the claims of this application will be found allowable and an early favorable action is respectfully requested.

Respectfully submitted,

HAROLD W. MATTINGLY,
Attorney for Applicant.

HWM:MM
Encl. Graph


162699
COMPANY
WELL
Date Tested
Time
CASING PRESSURE 40 LBS. PER SQ. IN.
DEPTHOGRAPH COMPANY
TUBING CATCHER 1850'
LINER TOP 1930'
PERFORATIONS
(NEGATIVE PULSATIONS)
FLUID LEVEL
(SMOOTH PULSATIONS)

Defendant's Exhibit T—(Continued)

Div. 5 Room 3077 260 CLJ/HMR

Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name

Paper No. 5
All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Department of Commerce
United States Patent Office
Washington
June 15, 1938

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE,
Commissioner of Patents.

Mailed Jun 15 1938

Harold W. Mattingly,
924 Pacific Finance Building,
621 S. Hope Street,
Los Angeles, California.

Applicant: Cranford P. Walker
Ser. No. 162,699
Filed Sept. 7, 1937
For Method and Means for Measuring The
Location of Obstructions in Wells.

Defendant's Exhibit T—(Continued)

Responsive to amendment of April 21, 1938.

Additional reference cited:

Lehr et al, 2,047,974 July 21, 1936 181/0.52

Claims 17, 18, 27, 31, 32 and 37 are canceled

Claims 1 to 16 (claims 14 to 16 being formerly held allowable) and claims 19 to 23 are, upon careful reconsideration, again rejected as pointed out in the last office letter.

In claim 1, for example, there are two method steps set forth of (a) "creating a pressure impulse in the well" and (b) "measuring the lapse of time." Now these two method steps are clearly shown to be old by Batcheller of record, and Lehr et al. above cited. The statement that the "impulse is variably selected" does not add anything patentable to the claim and is at most a mere functional statement. That the echo arrives at the recording point with sufficient energy to make a record is not new with applicant in view of Batcheller and Lehr. It does not involve invention to make several trials to determine which is the best amplitude of sound waves generated to give satisfactory results.

Applicant argues (amendment of April 21, 1938) that the "pressure impulse of arbitrarily selected magnitude as disclosed in Batcheller may produce a result" but only "by chance and accident." It is believed, however, that Batcheller could, by trial, determine just what "magnitude" would give suitable and useful results.

Defendant's Exhibit T—(Continued)

Claims 5 and 6 are further rejected as indefinite and improper in that the mere selecting of the best impulse is not such as to entitle applicant to a patent therefor. The "creating in the well of a series of pressure impulses" is understood merely to mean that preliminary impulses are created until a suitable one is found, then the method is carried out using the suitable impulse. It is not seen to be a part of the process to carry out experiments or tests to determine the best conditions for carrying out the method.

Claims 22 and 23 are again rejected as pointed out in the last office letter.

Claims 24 to 26, 28 to 30, 33 to 36, 38 and 39 are deemed to be allowable.

C. W. ROBINSON,
Examiner.

Defendant's Exhibit T—(Continued)

Mail Division Jun 17, 1938 U. S. Patent Office.
Received Jun 18 1938 Division 5. Paper No. 6.
Amendment B.

In the United States Patent Office
Division 5—Room 3077

Cranford P. Walker
Method and Means for Measuring
the Location of Obstructions
in Wells

Filed September 7, 1937
Serial No. 162,699.

Los Angeles, California
June 13, 1938

Hon. Commissioner of Patents
Washington, D. C.

Sir:

Supplementing the amendment dated April 19, 1938, please amend the above identified application as follows:

Add the following claims.

B1

10 ~~—40~~. In a device for measuring pressure waves in a fluid medium under static pressure, a diaphragm, a pressure-tight housing surrounding said diaphragm and having a window therein capable of passing light between the interior and exterior of the housing, said housing being divided by the diaphragm into two compartments, one on each side of the diaphragm, a medium entrance communicating with one compartment to directly expose

Defendant's Exhibit T—(Continued)

one face of the diaphragm to the medium, a by-pass extending between the compartments to equalize the static pressure of the medium on opposite faces of the diaphragm, light-reflecting means associated with the diaphragm, means for directing a light beam upon said reflecting means to reflect the beam through said window, means disposed exteriorly of said housing for receiving and translating the reflected beam, and means extending into said housing to adjust the position of said reflecting means to adjustably direct the reflected beam upon said receiving means.

11 ~~—41~~. In a device for measuring pressure waves in a fluid medium under static pressure, a diaphragm, a pressure-tight housing surrounding said diaphragm and having a window therein capable of passing light between the interior and exterior of the housing, said housing being devided by the diaphragm into two compartments, one on each side of the diaphragm, a medium entrance communicating with one compartment to directly expose one face of the diaphragm to the medium, a by-pass extending between the compartments to equalize the static pressure of the medium on opposite faces of the diaphragm, a light reflector associated with said diaphragm, means pivoting said reflector within the housing

^ ~~casing~~, means connecting said diaphragm and said reflector to move said reflector about its pivot in accordance with deflections of said diaphragm, means for projecting a beam of light upon said re-

Defendant's Exhibit T—(Continued)

flecting means to reflect said beam through said window, means disposed exteriorly of said housing for receiving and translating the reflected beam, and handle means projecting through said housing ~~casing~~ and accessible exteriorly thereof for adjusting said reflector pivot means to adjustably direct the reflected beam upon the receiving means.

REMARKS

New claims 40 and 41, inserted herewith, are drawn along the lines of claims 38 and 39, directed to the diaphragm housing and light beam reflecting mechanism shown particularly in Fig. 5 of the drawings, new claims 40 and 41 being directed to an important feature of this construction by which, even though the casing is of gas construction, the reflector may be readily adjusted from the exterior of the casing to direct the reflected beam of light to any suitable or desired position upon the screen or record tape. This is an important feature of the applicant's construction, particularly in view of the fact that the conditions encountered in different wells may vary through such wide limits that the reflector, properly positioned for measuring one well, will be so improperly positioned when used on another well as to throw the reflected light beam substantially off of the record chart or the screen. Hence, by providing the simple pivotal mounting for the fulcrum 30 for the reflector and employing the adjusting screw 33, accessible from the exterior

Defendant's Exhibit T—(Continued)

of the housing, the fulcrum point may be so readily changed as to permit direction of the beam to a desired position (usually centrally) of the record chart. The necessity for such adjustment is occasioned by the fact that the casing for the instrument must be gas tight and ordinary adjustment devices would not operate under these conditions.

In reconsidering the rejection of claims 1-6 the Examiner's attention is called to the fact, more clearly brought out in the remarks accompanying the amendment of April 19, 1938, that the normal gas pressure existing in different wells varies through such wide limits that it is necessary to select a pressure impulse value which must vary also within wide limits. In actual practice the applicant has discovered that a pressure impulse of only ten pounds may be perfectly satisfactory on one well while on other wells it has been necessary to use a pressure impulse in the nature of 600 pounds. For this reason it is evident that the Batchellor device, disclosing only the employment of a cartridge as the means for producing a sound wave or a pressure impulse, could not be successfully used for the measurements obtained by the applicant and that the claims of this application directed to the method and apparatus for producing pressure impulses of varying magnitude defines an important advance in this art over any of the teachings in the Batchellor patent.

Upon reconsideration it is believed that all of the claims heretofore presented and the two addi-

Defendant's Exhibit T—(Continued)

tional claims 40 and 41 presented herewith will be found allowable.

An early, favorable action is requested.

Respectfully submitted,

HAROLD W. MATTINGLY,
Attorney for Applicant.

HWM mm

Div. 5—Room 3077 260

Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name

CLJ/H

Defendant's Exhibit T—(Continued)

Paper No. 7

All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Department of Commerce
United States Patent Office
Washington

Sept. 12, 1938

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE,
Commissioner of Patents.

Harold W. Mattingly
924 Pacific Finance Bldg.
621 S. Hope Street
Los Angeles, Calif.

Applicant: Cranford P. Walker
Ser. No. 162,699
Filed Sept. 7, 1937
For Method and Means for Measuring the Location of Obstructions in Wells.

Mailed Sep 12 1938

Responsive to amendment filed June 17, 1938.
It is noted that the amendment received June

Defendant's Exhibit T—(Continued)

17, 1938, is not responsive to the office action of June 15, 1938.

Complete response to the office action of June 15, 1938, must be made within the statutory six months period in order to save this case from abandonment.

C. W. ROBINSON,
Examiner.

Received Dec 13 1938 Division 5, Paper No. 8 Amendment C.

Mail Division Dec 12 1938 U. S. Patent Office.

In the United States Patent Office
Division 5—Room 3077

CRANFORD P. WALKER
METHOD AND MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Filed September 7, 1937
Serial No. 162,699

Los Angeles, California
December 8th, 1938

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In response to the Office action of June 15, 1938, please amend the above entitled application as follows:

Defendant's Exhibit T—(Continued)

Cancel Claims 1, 2 and 3 and substitute the following:

(C)

—42. The method of determining the unknown location of an obstruction in a well which has a restricted passage therethrough, which consists in creating in the well a series of pressure impulses of varying magnitude, observing the echoes of each impulse to select one pressure impulse amplitude which produces an echo from the unknown obstruction readily distinguishable from other echoes of that impulse, and measuring the lapse of time between the creation of the selected impulse and the arrival at a predetermined point of the echo from the unknown obstruction.—

Cancel Claims 4, 5 and 6 and substitute the following:

(E)

—43. The method of accurately determining the location of obstructions in wells, which consists in creating in the well a series of pressure impulses each of different amplitude, observing the echoes thereof from different obstructions in the well to select that amplitude of impulse which produces echoes from the different obstructions distinguishable one from the other, then utilizing said selected amplitude for measuring the lapsed time between the creation of the impulse and the arrival at a predetermined point of each of the distinguishable echoes to measure the distance from

Defendant's Exhibit T—(Continued)

said predetermined point to each of the different obstructions.—

Cancel Claims 7, 8 and 9 and substitute the following:

—44. The method of determining the unknown location of an obstruction in a well (~~E²~~) having another obstruction therein at a known location, annular space an acoustical which consists in creating in the ~~well a pressure~~ impulse of such magnitude as compared with the depth of the well and the resistance to pressure wave transmission therethrough as will produce echoes from different obstructions distinguishable from each other, observing the lapse of time between the creation of the impulse and the arrival at a predetermined point of the echo from the known obstruction to thereby determine the velocity of the pressure wave in that particular well, and measuring the lapse of time between the creation of the impulse and the arrival at said predetermined point of the echo from the unknown obstruction.—

Cancel Claims 10 and 11 and substitute the following:

—45. The method of determining the unknown location of an obstruction in a well containing a gaseous medium and having an obstruction therein at a known location below the ground surface, which consists in creating the pressure impulse in the well at the ground surface, observing the lapse of time between the creating of the impulse and the arrival at the ground surface of an echo from the

Defendant's Exhibit T—(Continued)

~~known obstruction to thereby determine the ve~~locity of the pressure wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at the ground surface of the echo from the unknown obstruction.—

Cancel Claim 12 and substitute the following:

—46. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating ∧ ~~a pres~~ an acoustical annular space between the tubing and the casing in the ~~sure~~ impulse in the ∧ well of such magnitude as compared with the depth of the well and the resistance to pressure wave transmission therethrough as will produce echoes from portions of the tubing string distinguishable from the echo from the unknown obstruction, observing the lapse of time between the creation of the impulse and the echoes from successive portions of the tubing string to thereby determine the velocity of the pressure wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo from the unknown obstruction.—

Cancel Claim 13 and substitute the following:

—47. The method of accurately determining the unknown location of an obstruction in a well having a string of tubing therein constructed of a plurality of lengths of tubing, each of approximately

Defendant's Exhibit T—(Continued)

the same length and connected to each other by couplings, which consists in creating a pressure impulse in the well, noting the lapse of time between the creation of the impulse and the arrival at a predetermined point of the echoes from the successive couplings of the tubing lengths to accurately determine the velocity of the pressure wave through the different portions of the well, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.—

Insert the following claim between Claims 14 and 15:

—48. The method of determining the unknown location of an obstruction in a well containing a gaseous medium, which consists in determining the velocity of pressure waves through the gaseous medium in the well under measurement, creating a pressure impulse in the well, and noting the lapse of time between the creation of the impulse and the arrival at a predetermined point of the echo from the unknown obstruction.—

Claim 16, Lines 5 and 6, change "lengthening or shortening" to read—adjusting the length of—

Insert the following claims between Claims 15 and 16:

—49. The method of accurately determining the unknown location of an obstruction in a well having a string of tubing therein constructed of a plurality of lengths of tubing, each of approxi-

Defendant's Exhibit T—(Continued)

~~mately the same length, which consists in creating~~ a pressure impulse in the well, providing a pressure responsive device in communication with the well to receive and translate the echoes from the various obstructions therein and so tuned to the frequency of the echoes from the couplings of the tubing sections as to clearly distinguish the echoes from the couplings from each other to thereby determine the velocity of the pressure wave within the particular well under measurement, and noting the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo from the unknown obstruction.

—50. The method of accurately determining the unknown location of an obstruction in a well having a string of tubing therein constructed of a plurality of lengths of tubing, each of approximately the same length, which consists in creating a pressure impulse in the well, coupling the well to a pressure responsive device to translate echoes from the several obstructions in the well, so tuning the pressure responsive device to the frequency of the echoes received from the couplings of the tubing sections as to accent these echoes, noting the frequency of the echoes from the couplings of the tubing sections to determine the velocity of the pressure wave in the particular well under measurement, and noting the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo from the unknown obstruction.

Defendant's Exhibit T—(Continued)

—51. An apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means for creating a pressure impulse in said well, echo receiving means including a pressure responsive device exposed to said well for receiving pressure impulses from the well and for measuring the lapse of time between the creation of the impulse and the arrival at said receiving means of the echo from said obstruction, and means for so tuning said pressure responsive device to the frequency of the echoes from the couplings of the tubing sections as to clearly distinguish the echoes from the couplings from each other to thereby determine the velocity of the pressure wave within the particular well under measurement.

1 —~~52~~. In an ∧ ~~An~~ apparatus for determining the location of an obstruction in a well having ∧ therein a string of assembled tubing sections ∧ interconnected with each other by coupling collars ~~therein~~, means (∧E⁶) for creating ∧ a ~~the~~ pressure impulse in said well, echo receiving means including a pressure responsive device exposed to said well for receiving pressure impulses from the well and for measuring the lapse of time between the creation of the impulse and the arrival at said receiving means of the echo from said obstruction, and means associated with said pressure responsive device for tun-

Defendant's Exhibit T—(Continued)

~~ing said receiving means to the frequency of echoes~~ from the tubing collars of said tubing sections to clearly distinguish the echoes from said couplings from each other.—

Cancel Claims 20, 21, 22 and 23 and substitute the following claim:

—53. In an apparatus for determining the unknown location of an obstruction in a well, means communicating with said well at the well head ^ for creating pressure impulses in the well, means ^ for controlling the magnitude of the pressure impulses created in said well, a pressure responsive device coupled to said well and movable in response to pressure variations in said well, means for visually observing the movements of said pressure responsive device to thereby select the magnitude of pressure impulse for that well which will produce an echo from the unknown obstruction distinguishable from other pressure variations in the well, and means (^E[4]) ~~for measuring the lapse of time~~ between the creation of said selected impulse and the arrival at a predetermined point of the echo thereof from the ~~unknown obstruction.~~

Claim 24, Line 7, change "lengthening or shortening" to read—adjusting the length of—.

Claim 25, Line 7, change "lengthening or shortening" to read—adjusting the length of—.

Claim 16, Line 3, after "having" insert—located

Defendant's Exhibit T—(Continued)

~~therein—; same line, after "tubing" cancel "located~~ therein" and substitute—sections interconnected by coupling collars—; Line 9, change "couplings" to read—collars—.

REMARKS

This amendment is made not only to the Office action of June 15, 1938 but also in response to an oral interview had with the Assistant Examiner and the Primary Examiner about October 17, 1938.

As pointed out in that interview, this applicant has not merely presented for consideration a theoretical structure and a theoretical method of operation but has instead presented an application to cover methods and apparatus which he has developed and made available to the oil industry to provide this industry with accurate and reliable measurements, not only of the location of the fluid level or other obstructions in old existing wells but also accurate and reliable information as to the proper location for pumps, the fluid density at various points below the liquid surface and the only inexpensive method of determining the potential capacity of a well pumped by a mechanical pump.

The oil industry has welcomed his development, his organization and the service they perform, with open arms and have come to rely upon them for this information which is otherwise either totally unobtainable or obtainable only by such laborious and expensive means as to render it almost prohibitive. The applicant's methods and service have been used and are now being used by the major oil com-

Defendant's Exhibit T—(Continued)

panies and statements or affidavits can be obtained from them demonstrating that the applicant has supplied a long felt want in this industry.

Therefore, in considering the claims of this application, the Examiner must keep in mind that the applicant has advanced this art by performing for the first time new, accurate and reliable methods of obtaining important information for the industry and he is not to be denied patent protection upon his contributions unless the Examiner can show that the same concept of invention is disclosed in the prior art.

Taking up for consideration first the subject matter of Claims 14, 15 and 16, which the Examiner originally allowed but then in the Office action of June 15, 1938 blanketed with Claims 1 through 6, etc. in an unexplained rejection, the Examiner at the oral interview stated that such rejection of these claims was an inadvertent error though he pointed out some minor corrections which were needed in Claim 16. These corrections have been made.

The subject matter of Claims 14, 15 and 16, as well as new Claims 45, 46, 47, 48, 49, 50, 51 and 52, is directed to that step of the applicant's method which converts the inaccurate and unreliable results obtainable from the Batcheller and from the Lehr et al. practices to accurate and reliable measurements. The applicant in developing his system discovered that the results obtained were inaccurate because each well has a different gaseous medium therein and only by observing and measuring the actual velocity of

Defendant's Exhibit T—(Continued)

the pressure wave in the well under test is it possible to achieve accurate and reliable results. He provides three different ways of determining this velocity:

(1) separating the results of the echo from an obstruction at a known location within the well in some manner so as to render it distinguishable from the echo from the unknown obstruction or liquid surface. Thus by noting the time lapse required for the echo from the known obstruction he has an accurate measurement of the velocity of the pressure, not in oil wells in general but in that particular well under test. He has observed that the velocity in different wells may vary from 750 feet per second to 1400 feet per second so that unless the velocity in the well under test is known the results cannot be accurate;

(2) He provided a means for tuning the receiving instrument in such manner that the echoes from the tubing coupling collars were readily distinguishable one from the other so that by counting the tubing collar echoes in a given period of time he could accurately determine the pressure wave velocity; and

(3) He provided an instrument at the ground surface through which the gaseous medium in the well could pass and there made his determination of pressure wave velocity in that gaseous medium in the particular well under measurement.

Claim 48 is directed to the generic idea of combining the two steps (1) determining the velocity in the well under measurement and then (2) using this velocity in combination with the echo prin-

Defendant's Exhibit T—(Continued)

ciple to determine accurately the location of the unknown obstruction.

Claims 45 and 14 are directed specifically to the first of the three methods of determining the velocity noted above.

Claims 15, 46, 47, 49, 50, 51 and 52 are all directed specifically to the second method noted above for determining the pressure wave velocity, namely, the tuning of the receiving instrument so as to accent the tubing collar echoes and thus permit them to be distinguished from each other and to be counted.

At the oral interview the Examiner questioned Claim 14 as possibly aggregational but it is believed that not only Claim 14 but all of the remaining claims in this group are clearly and definitely a statement of steps which are dependent one upon the other to achieve the accurate result obtained by the applicant. It was the failure of the prior art to take into consideration this difference in velocity which kept the prior art methods from accomplishing any substantial advance in this art. Unless the Examiner can find a reference which teaches this concept of the invention, all of these claims must be allowed.

To assist the Examiner in the consideration of this group of Claims, new Claim 48 defines this method broadly while Claim 14 is specific in that it recites the observation of the echo from an obstruction of known location for the determination of the velocity.

Defendant's Exhibit T—(Continued)

Claim 49 is directed broadly to that method which includes the tuning of the receiving device to accent the echoes from the tubing couplings which may be accomplished by initially selecting a receiving device having the tuned characteristics.

Claim 50 is directed to the same subject matter as Claim 49 but brings out the additional step of variably tuning the receiving device after it is coupled to the well.

Claim 51 is an apparatus claim similar to allowed Claims 24, 25 and 26, and defines the receiving device with a "means" for tuning the receiving device. Claims 24 and 25 are directed more specifically to this tuning by the adjustment of the length of the coupling between the pressure responsive device and the well.

Each of these claims has been carefully drawn to distinguish one from the other and it is believed that the applicant is entitled to the protection afforded by each of these claims.

Now considering that group of claims directed to the employment of a succession of impulses of different magnitude, the Examiner rejected Claims 1 through 6, etc. on the patents to Batcheller and Lehr et al., upon the ground that it would not amount to invention to make several trials to determine which is the best amplitude to give satisfactory results. All of the claims directed to this subject have been cancelled and new Claims 42, 43, 44, 45, 46 and 53 have been substituted therefor. In each of these claims it has been carefully brought

Defendant's Exhibit T—(Continued)

out that it is not a mere selection of a pressure impulse of one magnitude or another magnitude by a cut and try method but instead what is sought to be covered is the selection of an impulse and the observation of the effect of this impuse to determine when an impulse has been found which will give clearly distinguishable echoes from different obstructions in the well.

Upon reviewing Claims 1 through 6, etc. directed to this subject matter, it is believed that these claims did not properly bring out the applicant's real contribution in this line but that new Claims 42 through 46 and 53 do properly set forth this contribution. Again the Examiner's attention is called to the fact that the applicant discovered the reasons for the failures in prior attempts to use the pressure echo method for obtaining these results, namely, that each well had different characteristics from those of other wells and that improper magnitude of impulse would give either no results or results which could scarcely be read. By introducing that new step, namely, of variably selecting the amplitude, observing the effects of the amplitude, he could change failure into success. It is believed that the new claims bring out this contribution and that each of them is clearly allowable.

Claim 42 is directed broadly to this new step.

Claim 43 is directed to the subsequent utilization of an impulse the magnitude of which has been previously determined as set forth.

Claim 44 is directed broadly to the utilization of

Defendant's Exhibit T—(Continued)

an impulse selected in accordance with the known characteristics of the well with regard to depth and resistance to the pressure wave transmission to produce distinguishable echoes from different obstructions and thus permit the applicant to observe these distinguishable echoes as a means for determining pressure wave velocity.

Claim 45 is directed to the same subject matter as Claim 44 but defines the point of origin of the impulse and the point of reception of the echo as being at the ground surface.

Claim 46 is similar to Claims 44 and 45 but applies the method to a well containing a tubing string and selecting the impulse of such magnitude as will give distinguishable echoes from the different tubing sections.

Claim 47 is similar to Claim 46 but defines the feature that where the tubing sections are of the same known length the impulse produces distinguishable echoes from all of the tubing sections to permit the observation and determination of the velocity through different portions of the well.

All of these claims define steps and features which are not found in the prior art and it is their absence from the prior art knowledge which defines the difference between success and failure of the system.

Claim 53 has been substituted for Claims 20, 21, 22 and 23 and is directed to the apparatus by which the applicant can produce impulses of different magnitude, which includes means for producing

Defendant's Exhibit T—(Continued)

variable impulses and means for visually observing the movement of a pressure responsive device so as to determine when the distinguishable echoes are produced. This is a feature not contemplated in any of the prior art devices and this claim is also clearly allowable.

It is noted that no action has been taken upon newly submitted Claims 40 and 41 but it is pointed out in the amendment filed June 17, 1938 how each of these claims is clearly patentable over the art of record.

It is believed that upon reconsideration of this application, particularly in view of the careful presentation of each of the claims remaining in this case, it will be found that each of them is directed to and does define those differences over the prior art which makes the applicant's device a successful achievement in this industry and that each of the claims will be found to be allowable.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant.

HWM:MM

Defendant's Exhibit T—(Continued)
In the United States Patent Office
Division 5—Room 3077

Mail Division Dec 15 1938 U.S. Patent Office.

Received Dec 16 1938 Division 5, Paper No. 9, Amendment D.

Via Air Mail
Confirmation
Regular Mail

CRANFORD P. WALKER
METHOD AND MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Filed September 7, 1937
Serial No. 162,699

Los Angeles, California
December 13, 1938

Hon. Commissioner of Patents
Washington, D. C.

Sir:

Supplementing the amendment forwarded to the Patent Office in the above identified application on December 8, 1938, please amend said application as follows:

Cancel Claim 19.

REMARKS

It is noted that in the amendment filed in the above application, forwarded to the Patent Office on December 8, 1938, instruction to cancel Claim 19 was inadvertently omitted, the subject matter of

Defendant's Exhibit T—(Continued)

this claim being fully covered by new Claims 42 and 43.

Respectfully submitted,
HAROLD W. MATTINGLY
Attorney for Applicant.

HWM:MM

In the United States Patent Office

Application Div. U.S. Patent Office. Feb 9 '39.

Received Feb 9 - 1939, Division 5, Paper No. 10,

Amendment E.
In the application of
Cranford P. Walker

Method and Means for Measuring
the Location of Obstructions
in Wells

Filed Sept. 7, 1937
Serial No. 162,699

Div. 5
Room 3077
Washington, D. C.,
Feb. 9, 1939

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Supplementing the amendment of December 8, 1938, please amend the above entitled application as follows:

Cancel claims 42 and 43, and substitute the following:

Defendant's Exhibit T—(Continued)

E1

~~54. The method of determining the unknown lo~~cation of an obstruction in a well having a casing with tubing therein restricting the volume of the annular space within the casing and having an approximately known depth and a known pressure of gas within said space, from which the approximate magnitude of acoustical impulse required to traverse the restricted space and produce echoes from the several obstructions in the well may be determined, which consists in introducing into said space between the casing and tubing a series of acoustical impulses, each of different magniture approximating the determined magnitude to produce from each impulse echoes from the different obstructions in the well, observing the echoes that are produced by each impulse to select the one that produces distinguishable echoes from each of the obstructions in the well, and recording the echoes of an impulse of the selected magnitude in the relative times and order in which they are received at the ground surface.

Claim 44, line 2, after "well" insert

E2

—having a casing with tubing therein restricting the volume of the annular space within the casing and

—; line 4, cancel "well a pressure" and substitute —annular space on acoustical—.

Cancel claim 45.

Defendant's Exhibit T—(Continued)

Claim 46, line 3 cancel "a pressure" and substitute—an acoustical—; line 4, before "well" insert —annular space between the tubing and the casing in the—.

Cancel claim 47 and substitute the following:

E3

~~55 56. The method of accurately determining the~~ unknown location of an obstruction in a well having a string of tubing therein constructed of a plurality of lengths of tubing, each of approximately the same length and connected to each other by couplings, which consists in creating a pressure impulse in the annular space between the tubing and casing of the well, recording the echoes from the tubing collars and from said obstruction, and counting the tubing collar echoes between the creation of the pressure impulse and the echo from the unknown obstruction, to determine the location of the un~~known obstruction.~~

Cancel claim 51.

Claim 52, line 2 after "having" insert—therein—; line 3, cancel "therein" and substitute—interconnected with each other by coupling collars—; line 3 after "means" insert

E6

—communicating with said well—.

Claim 53, line 3 after "head" insert —communicating with said well—; line 4, after "means" insert —associated with said impulse creating means —; cancel from "for" in line 12 to end of the claim and substiute the following

Defendant's Exhibit T—(Continued)

E4

~~—associated with the said pressure responsive device~~ for recording the echoes in the relative times and order in which they are received by the ~~pressure responsive device—~~.

Claim 16, line 7, change "coupling" to read —pressure responsive device—.

Claim 24, line 3 after "means" insert —communicating with said well—; line 8, change "pipe" to read —pressure responsive device—.

Claim 25, line 3 after "means" insert —communicating with said well—; line 8 change "pipe" to read —pressure responsive device—; line 10, after "means" insert —associated with said pressure responsive device—.

Claim 26, line 3 after "means" insert —communicating with said well—; line 6, change "pipe coupling" to read —means intercoupling—; line 6, change "to" to read —with—; line 7, change "pipe" to read —pressure responsive device—; line 8, change "impulses" to read —impulse—; line 10, after "means" insert —associated with said pressure responsive device—.

Claim 28, line 2 after "means" insert —communicating with said well—.

Claim 29, line 2, after "means" insert —communicating with said well—.

Claim 30, line 2, after "means" insert —communicating with said well—.

Claims 34 and 35, lines 3 after "means" insert

Defendant's Exhibit T—(Continued)

—communicating with said tube—; lines 4, after "means" insert —associated with said tube—; line 5, after "means" (first occurrence) insert —associated with said pressure wave creating means—; lines 4 5, after "means" (second occurrence) insert —communicating with said tube—.

Claim 36, line 3 after "means" insert —communicating with said tube—; line 4, after "means" insert —associated with said tube—; line 5, after "means" insert —associated with said pressure wave creating means—.

Add the following claims:

E5

~~56. In an apparatus for determining the location~~ of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure impulse receiving means responsive to echoes from the couplings of the tubing string and to the echoes from other obstructions, means coupling said pressure receiving means to the well to expose said device to pressure variations existing in said well, and means associated with said device for recording the echoes to permit counting ~~of the same.~~

12 ~~57~~. In an apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure responsive device for receiving pressure impulses from the well, means cou-

Defendant's Exhibit T—(Continued)

pling said pressure responsive device to the well to expose said device to pressure variations existing in said well and having a length approximately a multiple of the length of a tubing section to tune said device to the frequency of the echoes of the impulse received from the couplings of the tubing string, and means associated with said device for recording the echoes from the tubing couplings and from said obstruction to permit counting the coupling echoes between the creation of the impulse and the echo from the unknown obstruction to determine its location.

REMARKS.

This is to acknowledge the interview courteously granted by the Examiner on February 7th, at which time the applicant and the attorney of record, presented to the Examiner some of the history of the development of the invention claimed in this application and the importance thereof to the oil industry.

At that interview, the claims of this application were carefully reviewed and discussed with the Examiner and in view of the suggestions made by the Examiner all of the allowed claims have been amended to more clearly bring out the association of the interrelation of the various elements recited, and to avoid the criticism of functionality. In this respect the Examiner's suggestions are sincerely appreciated.

With regard to that part of the subject matter of the applicant's invention relating to the desirability

Defendant's Exhibit T—(Continued)

and the necessity for employing impulses of various magnitude in order to produce a group of recordable echoes in which the echoes of each of the different obstructions such as tubing collars or couplings, tubing catches, liner tops and liquid surface can be readily distinguished from each other. It was pointed out to the Examiner that when measurements are to be made in a well of relatively shallow depth and in which the annular space between the walls of the casing and the walls of the tubing is relatively great an impulse of great magnitude produces such reverberations as to confuse the echoes received from these different obstructions and in such case an impulse of small magnitude must be used. On the other hand where the well is deep or where the annular space is restricted an impulse of greater magnitude is required and may be successfully employed without producing the confusing reverberations. Again, in some wells in which the gas pressure is relatively high an impulse of small magnitude will produce successful results while an impulse of great magnitude produces only confusion.

It was failure of the prior art as exhibited in Batchellor and Lehr et al patents which prevented these devices from being successfully used, even though the oil industry was constantly seeking a ready method of making fuel level determinations and made many attempts to apply the teachings of the Batchellor and Lehr et al patents for this purpose.

Defendant's Exhibit T—(Continued)

Claims 42 and 43 which presented this subject matter have been canceled and a new claim 54 has been substituted which it is believed expresses this phase of the applicant's invention properly. Again, the suggestions of the Examiner relative to the character of this claim are appreciated.

New claim 55 is presented herewith directed to the same subject matter as allowed claim 26, but particularly directed to the feature of employing the distinct echoes from the tube collars or couplings as a means of determining the location of the liquid level or other obstruction by counting the number of tube collar echoes received. This subject matter is disclosed on pages 19 and 20 of the original specification, and is believed to be clearly distinguished from any suggestion or teaching contained in the prior art.

New claims 56 and 57 are apparatus claims drawn to this same subject matter definitely setting forth the structure by which this result may be accomplished. Claim 56 defines the apparatus required to produce a distinguishable set of echoes from the tubing collars and for counting these echoes as the means for determining the location of the liquid surface, while new claim 57 brings in the additional structure required to "tune" the receiving device to accent these echoes so that they are more clearly distinguished from each other and can be more readily segregated and counted.

As was discussed with the Examiner at the inter-

Defendant's Exhibit T—(Continued)

view this applicant has produced for the first time a method and an apparatus which enables the oil industry to locate the position of the liquid surface, the position of tubing catchers, liner tops, pumps, perforated liners or other obstructions which may be in the well in an extremely inexpensive manner and which has been welcomed and adopted by the oil industry as the solution for the heretofore vexing and unsolved problem to obtain accurate information of this character. The applicant is prepared to submit affidavits, not only showing the immediate adoption and use of the applicant's method and apparatus by the major oil companies in the United States, but also their enthusiastic welcoming of this invention as the solution of one of their vexing problems which has caused great loss of time and great loss of money to the industry.

It is believed that upon reconsideration of this application in the light of the foregoing amendments, and the arguments presented in this case, each of the claims now presented will be found allowable, and an early and favorable action is requested.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney.

Received Feb 15 1939 Division 5. Paper No. 11

Pet. to Make Special.

In the United States Patent Office

Cranford P. Walker

Defendant's Exhibit T—(Continued)

Method and Means for Measuring the Location of Obstructions in Wells

Filed September 7, 1937

Serial No. 162,699

PETITION TO MAKE APPLICATION SPECIAL

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Now comes your petitioner, by his attorney of record, and requests that this application be made special for examination, and that the Examiner in charge thereof be instructed to take this application up for action out of its regular turn.

Your petitioner avers that he is engaged in the business of making surveys of oil wells to determine locations of the fluid levels and the locations of other obstructions in the wells by the use of sonic echo methods and apparatus, as set forth and claimed in this application.

That applicant's methods and apparatus as described and claimed in this application have met with instant commercial success and has been adopted as standard practice by the major oil companies of the United States.

That until applicant introduced his apparatus and methods to the oil industry, no similar method and apparatus was known to the industry.

That, subsequent to applicant's introduction of

Defendant's Exhibit T—(Continued)

his methods and apparatus, representatives of a competitor, International Geophysics Inc., then engaged in a non-competitive activity, inspected applicant's apparatus and methods and took photographs of applicant's apparatus and, thereafter, entered the field with similar apparatus and similar methods of obtaining fluid level determinations and measurement of obstructions in wells.

That the competitor by reason of the employment of the apparatus and methods is seriously damaging and threatens to destroy applicant's business and to deprive the oil industry and the public from receiving the benefits of applicant's invention and to injure the oil industry to an extent unless these activities can be controlled by patents and licenses thereunder.

That, in the opinion of your petitioner and his attorney of record, the apparatus and the methods practiced by the competitor constitutes an infringement of each and every of the claims now presented in this application.

That, until the patent is granted to applicant he is helpless to prevent this destructive competition.

That your petitioner further avers he has actively and diligently prosecuted this application by prompt amendments and by attempts to secure personal interviews with the Examiner in charge thereof for the purpose of expediting the prosecution of this case.

Your petitioner further avers that both he and his attorney of record have diligently searched the

Defendant's Exhibit T—(Continued)

prior art and, in the opinion of his attorney of record, each and every of the claims now presented in this application is patentable.

That in a companion application filed by your petitioner, Cranford P. Walker, on October 26, 1937, Serial No. 171,170, entitled Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells, a similar petition to make that application special was filed and attached thereto were affidavits and exhibits establishing the infringing activities of the same competitor, International Geophysics Inc., and evidence tending to establish applicant's priority in this field. It is requested that the said affidavits and exhibits be considered as a part of this petition and to make this application special.

Attached hereto and made a part hereof are affidavits by Cranford P. Walker and Harold W. Mattingly, his attorney of record, establishing the facts set forth in this petition.

Respectfully submitted,

CRANFORD P. WALKER

By HAROLD W. MATTINGLY

His Attorney

Washington, D. C.,
February 11, 1939.

Defendant's Exhibit T—(Continued)
Mail Division Feb 11 1939 U.S. Patent Office.
In the United States Patent Office

CRANFORD P. WALKER

METHOD AND MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Filed September 7, 1937.

Serial No. 162,699

AFFIDAVIT OF CRANFORD P. WALKER

Cranford P. Walker, being duly sworn, deposes and says that he is the applicant named in the above-entitled application for United States Letters Patent.

That on February 11, 1939, he filed a petition to make application special in the matter of his co-pending application, Serial No. 171,170, filed October 26, 1937, for Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells, and he adopts as a part of this affidavit each and every of the statements set forth in his affidavit accompanying that petition.

Affiant further states that he has personally inspected the apparatus employed by the competitors, International Geophysics Inc., and that the same incorporates mechanism for producing pressure waves in wells, mechanism for recording the same, and mechanism for tuning instruments to accent the echoes from tubing collars or similar regularly spaced obstructions in the wells.

Defendant's Exhibit T—(Continued)

That, in his opinion, the apparatus employed by the competitor constitutes an infringement of claims 24, 25 and 26 which have been allowed in this application.

CRANFORD P. WALKER

Sworn to and subscribed before me this 11th day of February, 1939.

FREDERICK A. ALLMITT
Notary Public

In the United States Patent Office

CRANFORD P. WALKER

METHOD AND MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Filed September 7, 1937

Serial No. 162,699

AFFIDAVIT OF HAROLD W. MATTINGLY

Harold W. Mattingly, being duly sworn, deposes and says that he is the attorney of record in the above-entitled application.

That, on February 11, 1939, he filed a petition to make a copending application special for Cranford P. Walker, Serial No. 171,170, filed October 26, 1937, for Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells, and adopts herein each of the statements made in affiant's affidavit attached to that petition.

Defendant's Exhibit T—(Continued)

That, in addition thereto, affiant has carefully compared the evidence submitted to him including the photographs accompanying the said petition and, in his opinion, the competitor, International Geophysics Inc., is clearly infringing claims 26, 27 and 28 of this application.

That the said claims have been allowed by the Patent Office and that affiant has caused to be made a thorough seach of the prior art and believes that each of the said claims is patentable to applicant.

HAROLD W. MATTINGLY

Sworn to and subscribed before me this 11th day of February, 1939.

FREDERICK A, ALLMITT
Notary Public.

Div. 5
Cranford P. Walker,
Ser. No. 162,699
Received Feb 15 1939 Division 5, Paper No.
The examiner will please send the file of this ap-
Mrs. Peterson, Room 3898
plication to ~~Mr. E. T. Newton, Room 3628,~~ indicating hereon when the application will be reached for action.

CONWAY P. COE
Commissioner.

Defendant's Exhibit T—(Continued)

This application will be acted upon within 3 weeks

Date Feb. 13 1939

[Longhand Note]: (for Division) only? J.W.M.

C. L. JUSTUS

(To be signed by person reporting.)

Department of Commerce
United States Patent Office
Washington
Address only the Commisioner of Patents
Washington, D. C.

U.S. Patent Office Commissioner's Office Feb 13 1939 Copy Mailed.

Received Feb 15 1939 Division 5, Paper No. 12 Com's Dec. (Pet. Granted)

Feb 13 1939

Ex parte Cranford P. Walker,
Serial No. 162,699,
Filed September 7, 1937,
Method and Means for Measuring
the Location of Obstructions in Wells.

PETITION TO MAKE SPECIAL.

The petition to make this case special has been considered.

If the examiner can make this case special without prejudice to any possible interfering applica-

Defendant's Exhibit T—(Continued)

tions, and he should make a rigid search for such, he is authorized to do so for the next action. Should the application be rejected again, the case will not be considered special for the subsequent action unless the applicant promptly makes a bona fide effort to place the case in condition for allowance even if it is necessary to have an interview with the examiner to accomplish this purpose.

If the examiner finds any interfering application for the same subject matter, he should consider such application simultaneously with this case and should state in the official letter of such application that he is taking it out of its turn because of a possible interference.

The petition is granted.

JUSTICE W. MACKLIN
First Assistant Commissioner.

Mr. Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope St.,
Los Angeles, Calif.

Defendant's Exhibit T—(Continued)

260

Department of Commerce
United States Patent Office
Washington
Div. 5 Room 3077
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name
Paper No. 13
All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Feb. 21, 1939

CLJ/H

Please find below a communication from the EXAMINER in charge of this application.

CONWAY P. COE
Commissioner of Patents,

Harold W. Mattingly
924 Pacific Finance Bldg.
621 S. Hope Street
Los Angeles, Calif.

Applicant: Cranford P. Walker
Ser. No. 162,699,
Filed Sept 7, 1937
For Method and Means for
Measuring the Location of Obstructions in Wells

Mailed Feb 21 1939

Defendant's Exhibit T—(Continued)

Responsive to amendments filed December 12 and 15, 1938, and February 9, 1939.

The amendment of February 9, 1939, contains two claims 56, and the first one, to be substituted for claim 47, is renumbered by the examiner as claim 55 and will be so designated hereafter.

Claims 1 to 13, 17 to 23, 27, 31, 32, 37, 42, 43, 45, 47 and 51 are canceled.

Division is required between the claims as follows:

Group I, claims 14 to 16, 24 to 26, 28 to 30, 44, 46, 48 to 50 and 52 to 57 as drawn to a method and apparatus for determining the location of obstructions in wells; and

Group II, claims 33 to 36, 38 to 41 as drawn to a method and apparatus for determining the velocity of pressure waves in a given medium.

These two groups of claims are to separate and distinct inventions, each of which may be practiced without using the other.

Division is further required between the claims of Group I above as follows:

A. Claims 14 to 16, 46, 48 to 50, 54 and 55 drawn to the method; and

B. Claims 24 to 26, 28 to 30, 44, 52, 53, 56 and 57 drawn to apparatus for determining the unknown location of an obstruction in a well.

It is believed that the method and apparatus are two distinct and separate inventions, that the method can be carried out by other apparatus, and the apparatus can be used to carry out other methods.

Defendant's Exhibit T—(Continued)

Division is further required between the claims of Group II as follows:

A. Claim 33 drawn to a method; and

B. Claims 34 to 36 and 38 to 41 as drawn to an apparatus for measuring pressure wave velocity.

It is believed that the method and apparatus claims are to two separate and distinct inventions.

Claims 44, 46, 48 go 50 and 53 to 57 are rejected as being unpatentable over Lehr et al of record.

Considering claim 48, for example, the steps of "creating a pressure impulse in the well" and "noting the lapse of time" are the same as those recited in claim 9 of Lehr et al. The method step recited by applicant of "determining the velocity of pressure waves through the gaseous medium in the well" is a separate step and need not be performed with the other steps set forth. Furthermore, Lehr, on page 2 of his patent, discloses how the velocity of the impulse wave may be determined.

Claim 16 is rejected as indefinite in "adjusting the length of the coupling between the well and the pressure responsive device" implies that there is a definite structural element required to carry out the method step, yet that structure is not clearly set forth.

The above requirement for division constitutes a rejection of the application under ex parte Steinmetz v. Allen, 109 O. G. 549; 1904 C. D. 703; 192 U. S. 543.

C. W. ROBINSON,
Examiner.

Defendant's Exhibit T—(Continued)

Application Div. Mar 6 '39. U. S. Patent Office.
Received Mar 6-1939. Division 5 Paper No. 14.

Amendment F.

In the United States Patent Office
Division 5—Room 3077

Cranford P. Walker
Method and Means for
Measuring the Location
of Obstructions in Wells
Filed September 7, 1937
Serial No. 162,699

Los Angeles, California
March 3, 1939

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In response to the Office action of February 21, 1939, please amend the above identified application as follows:

In the Petition, the preamble to the specification and the Oath, please change the title by striking out "Method And".

Page 1, Line 1, change "a method of" to read—devices for—; Line 3, cancel "methods and".

Page 3, Line 8, after "improve" insert—upon—; Line 12, cancel from "another" through the period in Line 26; Line 28, cancel "method" and substitute—device—.

Page 4, Lines 2, 10 and 24, change "a method and" and substitute—an—.

Defendant's Exhibit T—(Continued)

Page 5, cancel the paragraph beginning in Line 1 and ending in Line 7.

Page 12, Line 13, cancel "The pipe 18 is illustrated as being coupled" and substitute—A receiving device for receiving and registering the echoes of the pressure impulse from the various obstructions within the well is illustrated as including the pipe 18 and pressure responsive device coupled thereto—.

Page 14, line 7, after "and", delete the comma and insert—will cause the echo impulses to be registered for observation, both—; Line 8, delete the the comma and substitute—where—; Line 9, change "while" to read—and—.

Page 20, Line 2, change "of", first occurrence, to read—in—.

Cancel Claims 14, 15, 16, 33, 34, 35, 36, 44, 46, 48, 49, 50, 53, 54, 55 and 56.

Add the following claims:

13 —~~58~~. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from the couplings and other obstructions in said well, echo receiving and registering means coupled to said well to expose said receiving and registering means to pressure variations produced in said well by echoes from said obstructions, and means associated with

Defendant's Exhibit T—(Continued)

and registering

said receiving ∧ means to accent the registration of tubing coupling echoes.

14 —~~59~~. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from couplings and other obstructions in said well, pressure responsive echo receiving and registering means cou-

and registering

pled to said well to expose said receiving ∧ means to pressure variations in said well produced by echoes from said obstructions, and interference eliminating means associated with said receiving and registering

and registering

means for limiting the response of said receiving ∧ means to the registration of echoes from actual obstructions in the well whereby the registered echoes of the tubing couplings may be readily distinguished from each other and from the echoes from other actual obstructions in the well.

15 —~~60~~. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from the couplings and other obstructions in said well, pressure responsive echo receiving and registering means coupled

Defendant's Exhibit T—(Continued)

to said well to expose said receiving and registering means to the pressure variations produced in said well by echoes from said obstructions, and resonance means associated with said receiving and registering means to produce therein a natural acoustical period of oscillation so related to the frequency of the echoes from the tubing couplings as to accent the registration of the tubing coupling echoes.

16 —~~61~~. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating therein a pressure impulse to produce echoes of said impulse from the couplings and other obstructions in the well, echo receiving and registering means including a pressure responsive device, and pipe means coupling said pressure responsive device to said well to expose said device to pressure variations in the well, and means for adjusting the effective length of said pipe means to produce a natural acoustical period of oscillation of said pressure responsive device so related to the frequency of the echoes of said tubing couplings as to accent the registration of said echoes.

17 —~~62~~. In an apparatus for determining the unknown loaction of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating therein a pressure impulse to produce echoes of said impulse from the couplings and other obstructions in said well, pressure responsive

Defendant's Exhibit T—(Continued)

echo receiving and registering means having a natural frequency of oscillation so related to the frequency of the echoes from said tubing couplings as to accent the registration of said echoes, and means interconnecting said receiving and registering means to said well to expose said receiving and registering means to pressure variations in said well.—

Claims 24, 25 and 26, Line 7, before "length insert —effective—.

REMARKS

In view of the requirement for division contained in the Office action of February 21, 1939, the applicant has by this amendment limited all of the claims of this application to the apparatus for determining the location of obstructions in wells though the Examiner's attention is called to what is believed to be an inadvertent error in classifying Claims 38, 39, 40 and 41 with the claims indicated as Group II in the requirement for division. Claims 38 through 41, inclusive, are not directed to the calibrating tube mechanism (53, etc.) for measuring the velocity of the impulse in the particular gaseous medium but instead are directed to the receiving device 22 by which the echoes of the impulse are received and registered. It is believed that the Examiner did not intend to group these claims 38 to 41 with Claims 33 through 36, and for this reason these claims have been left in this application.

At the oral interviews had with the Examiner in charge of this application and with the Primary

Defendant's Exhibit T—(Continued)

during the week of February 6, 1939, the several phases of the invention disclosed in this application were thoroughly discussed and it was pointed out to the Examiner that one of the important features of the applicant's device was in so arranging the receiving mechanism that the tubing collar echoes were registered in a manner permitting them to be distinguished one from the other and also from the echoes of other obstructions existing in the well. It was pointed out that this was a feature which was not disclosed in any of the references of record in this application and was considered by the Examiner at these interviews to constitute allowable subject matter.

While allowed Claims 24, 25 and 26 are directed to this subject matter, it was suggested that claims could be presented to this feature which would clearly distinguish from the Batcheller and Lehr, et al patents, and for this reason new Claims 58, 59, 60, 61 and 62 are presented herewith.

Claim 58 defines this subject matter in clear and definite terms specifying all of the necessary elements for accomplishing the result of producing the echoes from the tubing collars which are distinguishable from each other by employing in combination with the receiver, means or mechanism which accents the echoes from the tubing collars.

Claim 59 recites this same structure but in more limited terms, specifying that this means or mechanism for permitting the distinguishable registration of the tubing collar echoes is an "interference

Defendant's Exhibit T—(Continued)

eliminating means" which limits the response of the receiver to the desired echoes and thus prevents interference with these registrations by extraneous disturbances such as harmonics and other reverberations, as specified on Page 20 of the original specification.

Claim 60 defines this same subject matter but limits the mechanism to a "resonance means" which produces a natural acoustical period of oscillation in the receiver so related to the frequency of the echoes from the tubing collars as to accent the registration of the tubing collar echoes.

Claim 61 is still more limited in that it specifies that the receiving means includes a pressure responsive device and also a pipe which couples the pressure responsive device to the well, with means for adjusting the effective length of this pipe to produce the necessary natural acoustical period of oscillation in the receiver.

Claim 62 is likewise directed to this same feature but defines the receiving and registering means as one which has the peculiar characteristic that it has a natural frequency of oscillation which will result in the accenting of the tubing collar echoes.

Upon review of Claims 24, 25 and 26, it is believed that these claims are rendered more accurate and definite by employing the word "effective" to define the adjustment of the length of the pipe or other coupling means employed to tune the receiving means to the tubing collar echoes. This amendment does not change the subject matter defined by these

Defendant's Exhibit T—(Continued)

claims and it is believed that each of them is clearly allowable over the references of record.

Claims 52 and 57 are likewise directed to this same subject matter but expresses the invention in somewhat different terms. Again, however, these claims are directed to the feature of producing distinguishable tubing collar echoes and are believed to be clearly patentable over the references of record.

At this point it is desired to call the Examiner's attention to the fact that the subject matter of each of Claims 52, 57 and 58 through 62 was considered and discussed with the Examiner at the oral interview and that the subject matter was considered to clearly define invention over all of the prior art patents of record as well as all of the art which was then available to the Examiner.

The only remaining claims in this application which have not been considered by the Examiner are Claims 40 and 41, both of these claims being directed to the particular construction of the applicant's pressure responsive device with its housing, together with the light reflecting mechanism so arranged that the light reflecting device may be adjusted from the exterior of the housing. These claims are drawn along the lines of allowed Claims 38 and 39 but include this additional feature of adjustment which has not been found in any of the references of record. It is believed that these claims are clearly allowable.

The attorney for applicant had hoped to be able

Defendant's Exhibit T—(Continued)

to present an amendment along the foregoing lines to the Examiner prior to the entry of an Office action and the amendment was partially prepared before the receipt of the Office action of February 21, 1939. However, the Examiner's prompt action on this application is sincerely appreciated since by this one amendment it is believed that all of the questions raised at the oral interviews have been completely answered and that this application is now presenting only the subject matter which was considered to be allowable.

In view of the fact that this application has been made special, it is requested that an early favorable action be entered in this case.

Respectfully submitted,

HAROLD W. MATTINGLY,

Attorney for Applicant.

HWM:MM

Defendant's Exhibit T—(Continued)

Mailed Mar 21 1939

H. Div. 5

Serial No. 162,699

81

Address only

The Commissioner of Patents

Washington, D. C.

Department of Commerce

United States Patent Office

Washington

March Twenty-one, 1939

Cranford P. Walker

Your Application for a patent for an Improvement in Means for Measuring the Location of Obstructions in Wells filed Sept. 7, 1937 has been examined and Allowed with 17 claims.

The final fee, Thirty Dollars, With $1 Additional for Each Claim Allowed in Excess of 20, must be paid not later than Six Months from the date of this present notice of allowance. If the final fee be not paid within that period, the patent will be withheld, but the application may be renewed within one year after the date of the original notice with a renewal fee of $30 and $1 additional for each claim in excess of 20.

The office delivers patents upon the day of their date, on which date their term begins to run. The preparation of the patent for final signing and sealing will require about four weeks, and such work will not be begun until after payment of the necessary final fee.

When the final fee is paid, there should also be

Defendant's Exhibit T—(Continued)

sent, Distinctly and Plainly Written, the name of the Inventor, Title of the Invention, and Serial Number as Above Given, Date of Allowance (which is the date of this circular), Date of Filing, and, if assigned, the Names of the Assignees.

If it is desired to have the patent issue to an Assignee or Assignees, an assignment containing a Request to that effect, together with the Fee for recording the same, must be filed in this office on or before the date of payment of the final fee.

After issue of the patent, uncertified copies of the drawings and specifications may be purchased at the price of Ten Cents Each. The money should accompany the order. Postage stamps will not be received.

The final fee will Not be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

Notice.—When the Number of Claims Allowed Is in Excess of 20, No Sum Less Than $30 Plus $1 Additional for Each Claim in Excess of Twenty Can Be Accepted as the Final Fee.

Respectfully,

CONWAY P. COE,

Commissioner of Patents.

[Printed in Margin]: In Remitting the Final Fee Give the Serial Number at the Head of This Notice.

[Printed in Margin]: Uncertified Checks Will Not Be Accepted.

Defendant's Exhibit T—(Continued)

Harold W. Mattingly
924 Pacific Finance Bldg.
621 S. Hope St.
Los Angeles, Calif.

Apr-3-39 197821 D nCheck—30.00
Walter P. Huntley MAdison 1137
Mail Division Apr 3 1939. U. S. Patent Office.

1/85

Harold V. Mattingly
Attorney at Law
Patent and Trademark Causes
621 South Hope Street
Los Angeles, California
March 30, 1939

Commissioner of Patents
Washington, D. C.

Sir:

Enclosed please find my check No. 1134 in the amount of $30.00, payment of the final Government fee in the matter of the application for United States Letters Patent for Means for Measuring the Location of Obstructions in Wells.

Name of Inventor—Cranford P. Walker
Serial No. 162,699
Filed September 7, 1937
Allowed—March 21, 1939, with 17 claims.

Respectfully,
HAROLD W. MATTINGLY.

MM

Defendant's Exhibit T—(Continued)

Received Apr 6-1939. Division 5, Paper No. 15. Pet (R-78) & Audt G.

Rule 78 Apr 7-1939. Orders No. 2698, 2801, 3311.

Via Air Mail
Confirmation
Regular Mail

U. S. Patent Office, Apr 5-1939. Issue Division.

In the United States Patent Office
Division 5—Room 3077

Cranford P. Walker
Method and Means for
Measuring the Location
of Obstructions in Wells
Filed September 7, 1937
Serial No. 162,699

Los Angeles, California
March 31, 1939

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In the above entitled matter, the following amendment is presented under the provisions of Rule 78:

Claim 41, Lines 12 and 19, change "casing" to read—housing—.

Claim 52, Line 1, cancel "An" and insert—In an—; Line 3, change "the" to read—a—.

Claim 58, Line 10, and Claim 59, Lines 8 and 12, after "receiving" insert —and registering—.

Defendant's Exhibit T—(Continued)

Claim 62, Line 6, change "coupling" to read —couplings—; Line 10, after "echoes" insert—,—.

[Marginal Note]: O. K., C. L. J.

REMARKS

In preparing this case for issue it was noted that in certain of the claims language had been used in the opening part of the claims to define elements which were later referred to by different names. The changes made as indicated will now make these definitions uniform throughout each of the claims. The other changes are to correct obvious grammatical errors.

Applicant respectfully submits that the amendments to these claims render them more accurate but do not alter or change the scope of the claims and will not require additional search.

It is therefore requested that these changes be entered in this application under the provisions of Rule 78.

Respectfully submitted,

HAROLD W. MATTINGLY,

Attorney for Applicant.

HWM:MM

Entered under Order 3311.

L. W. JOHNSTON,

Acting Examiner.

Defendant's Exhibit T—(Continued)

073

Div. 5 Room 3077 Paper No. 16

Department of Commerce
United States Patent Office
Washington

Mailed CLJ/H Apr 7-1939.

Address Only
The Commissioner of Patents
Washington, D. C.

Harold W. Mattingly
924 Pacific Finance Bldg.
621 S. Hope St.
Los Angeles, Calif.

Applicant: Cranford P. Walker
Ser. No. 162,699
Filed Sept. 7, 1937
For Means for Measuring the Location of Obstructions in Wells

Apr. 8, 1939

The amendment proposed under Rule 78 has been entered under authority of Commissioner's Order No. 3311.

L. W. JOHNSTON,
Acting Examiner.

[Printer's Note: Copy of Patent No. 2,156,519, issued to C. P. Walker for Means for Measuring the Location of Obstructions in Wells," attached here, is not reproduced, as it is set out in full as Plaintiff's Exhibit No. 1, in this Book of Exhibits.]

Defendant's Exhibit T—(Continued)

District Court of the United States
Southern District of California—Central Division

Honorable Commissioner of Patents,
Washington, D. C.

Sir:

In compliance with the Act of February 18, 1922 (42 Stat. L. 392), you are advised that there was filed on the 16th day of July, 1941, in this court an action, suit, or proceeding No. 1655-H-Civ., entitled:

Name Cranford P. Walker, etc., et al., Plaintiffs.
Address Los Angeles, California,

versus

Name Halliburton Oil Well Cementing Co., a Delaware corp., Defendant.

Address Los Angeles, California.

brought upon the following patents:

	Patent No.	Date of Patent	Patentee
1.	2,156,519	May 2, 1939	Cranford P. Walker
2.	2,161,733	June 6, 1939	Cranford P. Walker
3.	Reissue 21,383	Mar. 5, 1940	Cranford P. Walker

In the above-entitled case the following decision has been rendered or decree issued:

.....

.....

Defendant's Exhibit T—(Continued)

In Witness Whereof I have affixed my hand this 16th day of July, 1941, at Los Angeles, Calif.

R. S. ZIMMERMAN,
Clerk of said Court.
By L. WAYNE THOMAS,
L. Wayne Thomas, Deputy Clerk.

421
1937

CONTENTS

1. Application.....papers.
2. Print Sept. 11, 1939
3. Rejection Oct. 25/37
4. Amendment Apr. 21/38
5. Rejection June 15/38
6. Amendment B June 17/38
7. Letter Sept. 12/38
8. Amendment C Dec. 12/38
9. Amendment D Dec. 15/38
10. Amendment E Feb. 9/39
11. Let. to Mr. R. Special Feb. 11/39.
12. Com's Div. (Pet. Granted) Feb. 13/39
13. Rejection (Division) Feb. 21/39
14. Amendment F Mar. 6/39
15. Pet. (R-78) & Amdt. G Apr. 6/39
16. Letter (Aprvd.) Apr. 8/39
17. Notice of suit July 21-1941

[Endorsed]: Filed Nov. 10, 1942.

DEFENDANT'S EXHIBIT U

390

Department of Commerce
United States Patent Office

To all persons to whom these presents shall come,
Greeting:

This Is To Certify that the annexed is a true copy from the records of this office of the File Wrapper and Contents, in the matter of the

Letters Patent of
Paul E. Lehr and Harold T. Wyatt,
Number 2,047,974, Granted July 21, 1936,
for
Improvement in Methods and Apparatus for Measuring Well Depths.

In Testimony Whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this seventh day of November, in the year of our Lord one thousand nine hundred and forty-one and of the Independence of the United States of America the one hundred and sixty-sixth.

Attest:

D. E. WILSON,
Chief of Division.

[Seal] CONWAY P. COE,
Commissioner of Patents.

15

RE

NUMBER (Series of 1933)

696290

42

1933

PATENT NO. 2047974

DATED JUL 21 1936

(EX'R'S BOOK) 1-2-138-1

Name PAUL E. LEHR AND HAROLD T. WYATT

LONG BEACH,
CALIFORNIA

METHOD AND APPARATUS FOR MEASURING WELL DEPTHS

NOV 1 1936	97
NOV 1 1937	
Oct 22 1935	
Ex. No. 42	
Oct 30 1935	
3 Sep 1936	

Assignment and passed for Issue

Ex. No.

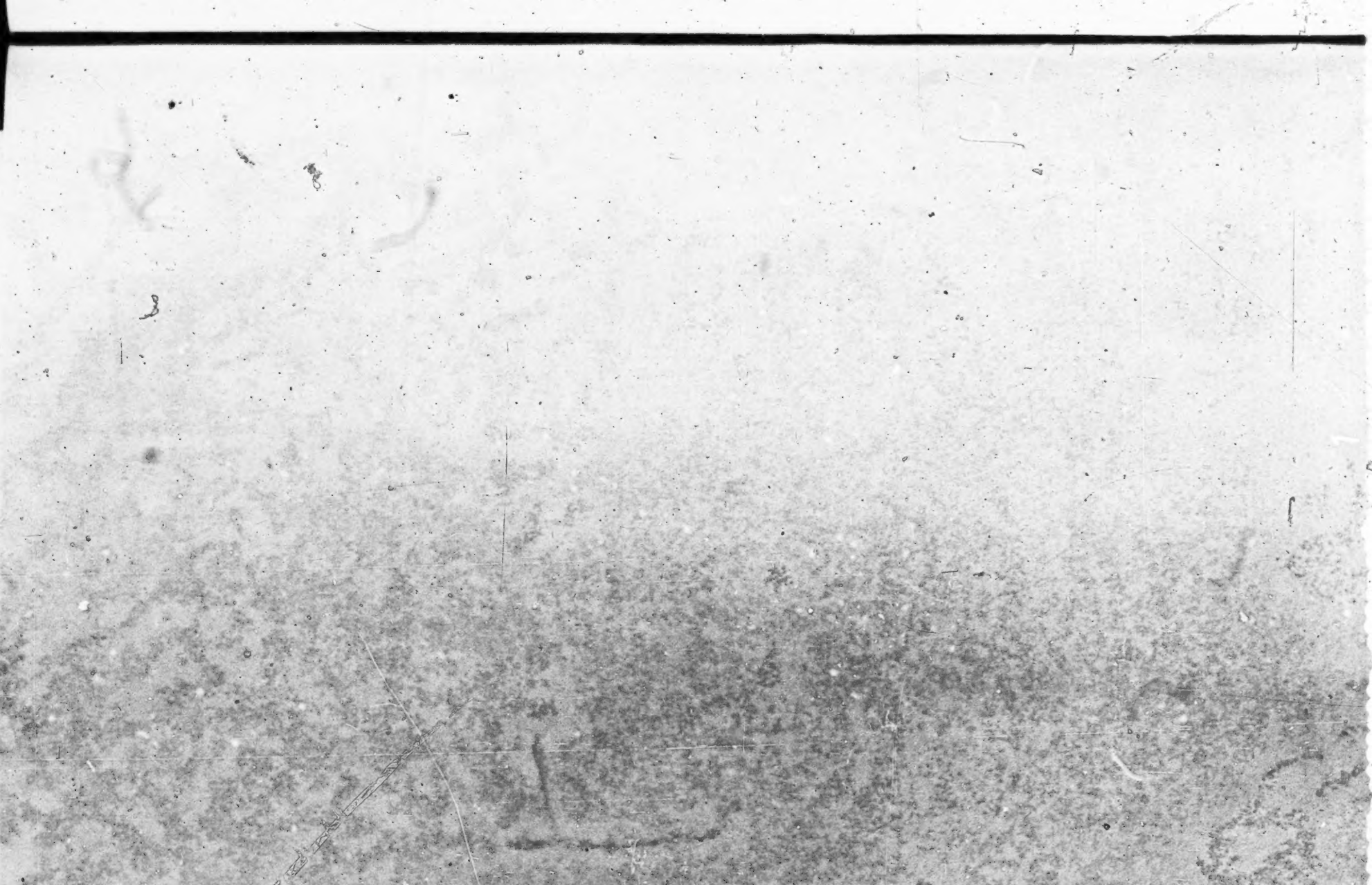
Notice of Allowance

Final Fee

LYNN AVENUE LOS NATIONAL CITY BANK BLDG. LOS ANGELES CALIF.

No. of Claims Allowed 9 Print Claims

Title of Invention Method and Apparatus for Measuring Well Depth



Defendant's Exhibit U—(Continued)

35/238

Nov-1-33 76340 K - Check — 30.00

Telephone
MIchigan 3901

Law Offices
Lyon & Lyon
Patent and Trade-Mark Causes
National City Bank Building
Los Angeles

Mail Division Nov. 1 33.
U. S. Patent Office.

Frederick S. Lyon
Leonard S. Lyon
Lewis E. Lyon
Richard F. Lyon

Henry S. Richmond
Irwin L. Fuller
Reginald E. Caughey
Casimir A. Miketta
Harold W. Mattingly

Francis D. Ammen
William A. Doble, Jr.
Eugene Woodbury

October 28, 1933

Commissioner of Patents
Washington, D. C.

Sir:

Attached is application for United States Letters Patent executed October 27, 1933 by Harold T. Wyatt and Paul E. Lehr for Method and Apparatus for Measuring Well Depths; also attached is our

Defendant's Exhibit U—(Continued)

check No. 5620 in the amount of $30.00 to cover the Government filing fee. (10 claims).

Respectfully,

LYON & LYON

EP
Enc

Mail Division Nov - 1 33 U. S. Patent Office.

PETITION AND POWER OF ATTORNEY

To the Hon. Commissioner of Patents:

Your petitioners, Paul E. Lehr and Harold T. Wyatt, citizens of the United States, residing at Long Beach, in the County of Los Angeles, and the State of California, whose post-office address is c/o Shell Oil Company, Higgins Building, Los Angeles, California, pray that letters patent may be granted to them for the Method and Apparatus for Measuring Well Depths set forth in the annexed specification, and they hereby appoint the firm of

Lyon & Lyon

(the individual members of which firm are Frederick S. Lyon, Leonard S. Lyon and Lewis E. Lyon), 708 National City Bank Building, Los Angeles, California, their attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.

Defendant's Exhibit U—(Continued)

Inventor sign full name:

HAROLD T. WYATT
PAUL E. LEHR

Specifications

To All Whom it May Concern

Be it known that

We, Paul E. Lehr and Harold T. Wyatt, residing at Long Beach, in the County of Los Angeles and State of California, have invented a new and useful

Method and Apparatus for
Measuring Well Depths

of which the following is a specification:

This invention relates to a method and apparatus for measuring distances and while the invention may be employed for different specific purposes, it is intended to be used particularly for measuring the depth of deep wells.

The usual method of measuring a well depth is by means of a sand line or a similar line let down onto the well. This consumes considerable time and labor.

It has been attempted to measure the depth of wells by using a sound wave method in accordance with which a sound is made at the mouth of the well and then the elapsed time is measured for this sound wave to pass to the bottom of the well and be reflected back to the mouth of the well. The sound wave method operates more perfectly in the-

Defendant's Exhibit U—(Continued)

ory than in practice for the reason that there is really very little energy in a sound wave and in deep wells this energy becomes so dissipated that the recording of the elapsed time becomes difficult. In using the sound method referred to, perhaps the crookedness of the well hole has considerable to do with the dissipation of the energy of the sound, causing considerable reflection and partial absorption of the sound waves as they pass down the well and return.

The general object of this invention is to provide a simple method and simple apparatus for ascertaining the distance to a distant surface from a local point, and particularly the distance from a well head to the liquid surface at the bottom of the well. It is frequently desirable during operations to ascertain the depth of the well measured to the surface of the liquid at its bottom and it is also frequently necessary to have this information in connection with pumping wells. The present method and apparatus affords means for determining well depths without the use of a sand line, and saving considerable labor; and without the use of a "sound method" which is more or less unreliable.

The invention may be practiced to advantage in shut down fields where it is important that a systematic series of fluid level observations be taken in order to locate those wells where the casing has failed and allowed water to enter.

Further objects of the invention will appear hereinafter.

Defendant's Exhibit U—(Continued)

As regards the apparatus, the invention consists in the novel parts and combination of parts to be described hereinafter, all of which contribute to produce an efficient apparatus for measuring well depths.

As regards the method, the invention consists in those novel steps and combinations of steps to be described hereinafter, all of which contribute to produce an efficient method for measuring well depths.

A preferred embodiment of the invention is described in the following specification, while the broad scope of the invention is pointed out in the appended claims.

In the drawings:

Figure 1 is a diagrammatic view illustrating a simple form of apparatus which may be employed in practicing the invention. This view shows some of the apparatus in side elevation and shows a portion of a well casing partly in elevation and partly in section, with certain parts broken away;

Figure 2 is a view similar to Figure 1 but illustrating indicating or recording apparatus for producing a record of the elapsed time in making the test;

Figure 3 is a view similar to Figure 2 but illustrating simple apparatus for enabling the invention to be practiced where the well is under pressure;

Figure 4 is a longitudinal section through a quick

Defendant's Exhibit U—(Continued)

opening valve or cock which may be of conventional type and which is employed in connection with the invention.

Before proceeding to a detail description of this invention, it should be stated that it employs the impulse wave principle, and the impulse wave is not generated by sound, but is generated by causing a sudden change in pressure at the well head. This change in pressure may be occasioned by a sudden liberation of a sufficient quantity of gas at the well mouth to cause a sudden substantial increase of pressure or a sudden decrease of static pressure within the the well head, and it may be accomplished so that only a slight change in pressure at the local point results. In either case this produces a pressure ^ ~~an~~ impulse wave immediately ~~originates~~ at the well head; and the elapsed time is observed for this wave to traverse the space from the local point or well head, to an obstruction such as liquid in the well, and return to the well head. If the well is not under pressure, we prefer to employ a confined quantity of fluid, preferably gas, and suddenly liberate a small quantity of it into the well head.

If the well has considerable pressure in it, as frequently exists in gas wells, the invention can be practiced by allowing a quantity of gas at the well head to escape suddenly into the atmosphere. If this is done, an expansion wave immediately originates at the well head, passes down to the surface of the liquid at the well bottom, and then travels up to the well head.

Defendant's Exhibit U—(Continued)

The elapsed time may be observed or indicated in any desired manner. If it is not desired to employ indicating instruments or recording instruments, a simple outlet can be provided at the well head, and a quantity of gas or air under pressure admitted suddenly into the well head, will, after a sufficient lapse of time, cause a perceptible puff of air or gas at the outlet. The elapsed time from the instant of admitting the gas or air under pressure until the occurrence of the puff at the outlet, will be the time consumed for the impulse wave to travel down and return from the bottom of the well. Such an impulse wave travels at the same velocity as sound, and if the elapsed time has been observed, it is possible, by employing a simple formula, to compute the depth of the well.

Referring more particularly to the parts and especially to Figure 1, 1 indicates a reservoir for any gas, for example, air, under considerable pressure, and this reservoir is connected through a suitable connection 2 with the valves 3, to an impulse chamber 4, being provided with a gauge 5 for indicating its internal pressure. The other end of this impulse chamber is connected through a quick opening valve or cock 6 to the well head or casing head 7. A flow pipe 8 may extend up through this casing head.

At any point on the periphery of the casing head an outlet 9 is provided to the atmosphere.

The valve 6 may be mounted in a pipe connection

Defendant's Exhibit U—(Continued)

10 which can be readily connected to the side of the casing.

In using the apparatus, the valve 6 should be closed and the valves 3 opened to permit a quantity of the compressed air or gas to accumulate in the impulse chamber 4, for example, at a pressure of one hundred pounds per square inch. The valves 3 would then be closed.

In making the test for determining the well depth, the valve 6 would be suddenly opened, thereby permitting a quantity of the compressed air or gas in the chamber to flow into the well head. This will produce an impulse wave which would pass downwardly as indicated by the arrows at the left side of the casing and this wave would eventually impinge upon the surface 11 at the well bottom 12 and would be reflected back toward the head of the well. When the impulse wave, after its reflection by the surface 11, arrives at the well head, a perceptible puff of the air or gas will occur at the outlet 9. This puff can be felt readily simply by holding one's hand in front of the outlet. At the instant that the valve 6 is opened a stop watch is started, and at the instant that the puff is felt at the outlet 9, the stop watch is stopped. The elapsed time will be the time required for the impulse wave to traverse the space from the local point at the well head to the surface 11, and return.

The velocity of this impulse wave will be substantially the same as that of a sound wave and can be computed by the following formula:

Defendant's Exhibit U—(Continued)

$$\text{Velocity} = \frac{Cp}{Cv} \times \frac{P}{D}$$

In this formula Cp equals the specific heat of the gas or air at constant pressure and Cv equals the specific heat of the gas or air at constant volume. The pressure P is usually expressed in pounds per square ft., and the density D of the gas would be expressed in pounds mass per cubic ft. This will express the velocity in ft. per second.

From this formula it is evident that the velocity of the impulse wave is independent of the pressure, for the reason that when the pressure is increased the density is also increased in the same proportion. If very accurate results are necessary, correction for temperature changes may be made according to well-known formulas.

If it is desired to have the result of the test indicated or recorded, this can be accomplished by providing a small pipe connection 13 (see Figure 2) which is attached to the casing 14 instead of the outlet 9, and this connection may carry a micro-

15

phone ~~13~~ which is electrically connected with an indicating or recording instrument 16. If desired, the circuit connection 17 between the microphone and the indicator or recorder 16 may include an amplifier 18 connected to conductors 19 and 20 of an electric power circuit.

The recorder 16 illustrated may be provided with a pen arm 21 which would be controlled by an impulse in the circuit 17, and this pen arm would

Defendant's Exhibit U—(Continued)

carry a pen or pencil 22 to run on the face of a recording drum 23 mounted to rotate on its horizontal axis in bearings 24.

This recording drum would be rotated at a uniform speed when the test was started, and the pen 22 would run in a straight line 25 on the drum and produce a laterally disposed peak in the line when the test started, and when the test ended by the return of the impulse wave from the bottom of the well. The test would be made in the same manner as that described in connection with Figure 1, and the apparatus used would be the same as illustrated at the left side of Figure 2.

If the well is under pressure, the invention can be practiced without the use of a high pressure gas, by merely permitting the quick exit of some of the gas in the well. This is illustrated in Figure 3 in which 26 indicates the well head which is provided at one side with a connection 27 carrying a quick opening valve or cock 28. The casing is provided with a pipe connection 29 carrying a ~~michrometer~~ microphone 30 with circuit wires 31 and 32 connecting it up to an amplifier and recording instrument. In practicing the invention, as illustrated in Figure 3, the sudden exit of a small quantity of gas under pressure from the interior of the head will cause an impulse wave to start from the well head, and thence to the liquid at the bottom of the well; this impulse will return, and the instant of arrival of this impulse wave at the well head 26 will be indicated by

Defendant's Exhibit U—(Continued)

microphone microphone
the ~~michromet~~ The ~~michrometer~~ and its connected indicating and recording instrument would also indicate the instant at which the valve 28 was open, thereby indicating the elapsed time. Hence, in using the formula in this case, also, it will be necessary to bear in mind that the impulse wave travels twice through the length or depth of the well.

In using the term "gas" in this specification and claims, it should be understood that the term, when used in its broad sense, is intended to include air which is, in fact, a gas.

It is understood that the embodiment of the invention described herein, is only one of the many embodiments this invention may take, and we do not wish to be limited in the practice of the invention, nor in the claims, to the particular embodiment set forth.

It is evident that our invention can be practiced also when the casing has atmospheric pressure within it or a partial vacuum, and with the same facility as when the well is under a high pressure.

What We Claim Is:—

~~1. A method of measuring the distance from a~~ local point to the surface of a distant object through maintaining a confined
a fluid medium which consists ∧ ~~in confining~~ a supply ~~of fluid under pressure, suddenly liberating a suffi-~~

Defendant's Exhibit U—(Continued)

~~cient quantity of the confined fluid at the local point~~, to cause a substantial change in the pressure at the local point and thereby producing ^ a pressure impulse wave in said medium due to the difference of pressure, and observing the elapsed time for the impulse wave to traverse the space between the local point and the object and return to the local point.

2. A method of measuring the distance to an obstruction or liquid in a well, which consists ^ maintaining a confined supply of gas under pressure ~~in confining gas~~ at the well's mouth, suddenly liberating a quantity of the said gas under pressure ^ at ~~into or out of~~ the well mouth and thereby producing a substantial change in pressure and an impulse wave in the gas in the well, and observing the elapsed time for the impulse wave to traverse the space from the head of the well to the obstruction, and ~~back again to the well's mouth~~.

~~1~~ 3. A method of measuring the depth of a well having a casing head and casing, which consists in (^B') ~~maintaining a confined supply of gas under pressure at the well head,~~ suddenly admitting a quantity of the said gas under pressure into the casing head and thereby producing a substantial change in static pressure and an impulse wave in the gas or air within the casing, ~~and observing the~~ elapsed time for the impulse wave to traverse the space from the casing head to the bottom of the well and back again to the casing head.

Defendant's Exhibit U—(Continued)

24. A method of measuring the depth of a well having a casing head and casing, which consists in confining a quantity of gas under pressure in the casing head, suddenly liberating a quantity of said gas and suddenly reducing the static pressure in the casing head and thereby producing an impulse wave in the gas within the casing, and observing the elapsed time for the impulse wave to traverse the space from the casing head to the well bottom and back to the casing head.

25. In apparatus for measuring the depth of a well, the combination of an impulse chamber ~~for~~ carrying a gas maintained under pressure, a connection from the impulse chamber to the ~~interior~~ head of the well including a quick opening valve, said well having an outlet to the atmosphere, said parts cooperating so that when the valve is suddenly opened, a ~~quantity of~~ portion of the gas under pressure will pass into the well and thereby raise the static pressure of the gas at the head of the well to produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, said impulse wave operating to produce a puff of gas at said outlet when the impulse wave arrives at the well head, ~~and~~ thereby enabling the elapsed time ~~for the wave to traverse the space to the well bottom,~~ during the wave's travel, to be observed.

Defendant's Exhibit U—(Continued)

4 ~~6~~. In apparatus for measuring the depth of a well, the combination of an impulse chamber ~~for~~ carrying a gas under pressure at the earth's surface, a connection from the impulse chamber to the head ~~interior~~ of the well including a quick opening valve, said well having an outlet to the atmosphere, said parts cooperating so that when the valve is suddenly opened, a portion of the ^ ~~quantity of~~ gas under pressure will pass into the well and thereby cause an increase of static pressure in the gas in the well head, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, and means for indicating the elapsed time for the wave to traverse the space to the well bottom and return ^ ~~back again to the surface~~.

5 ~~7~~. In apparatus for measuring the depth of a closed well, the combination of an impulse chamber ~~for~~ carrying a gas under pressure at the earth's surface, a connection from the impulse chamber to the head ~~interior~~ of the well including a quick opening valve, said parts cooperating so that when the valve is suddenly opened, a portion of the ^ ~~quantity of~~ gas under pressure will pass into the well and thereby cause a rise in the static pressure in the well head, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, and means connected with the well for indicating the

Defendant's Exhibit U—(Continued)

elapsed time for the wave to traverse the space to return the well bottom and ^ ~~back again~~ to the surface.

6 ~~8~~. In apparatus for measuring the depth of a closed well, the combination of an impulse chamber ~~for~~ carrying a gas under pressure, a connection from the impulse chamber to the interior of the well including a quick opening valve, said parts cooperating so that when the valve is suddenly opened, portion of the a ^ ~~quantity of~~ gas under pressure will pass into the well and thereby cause a rise in the well head static pressure, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, and a microphone connected with the well for indicating the instant the wave completes its travel within the well.

7 ~~9~~. In apparatus for measuring the depth of a closed well, the combination of an impulse chamber ~~for~~ carrying a gas under pressure, a connection from the impulse chamber to the interior of the well including a quick opening valve, said parts cooperating so that when the valve is suddenly opened, a portion of the ^ ~~quantity of~~ gas under pressure will pass into the well and thereby raise the static pressure in the well head, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, a microphone connected with the well, and a recording device electrically connected with the microphone.

Defendant's Exhibit U—(Continued)

8 ~~10~~. In apparatus for measuring the depth of a closed well, the combination of an impulse chamber ~~for~~ carrying a gas under pressure, a connection from the impulse chamber to the interior of the well including a quick opening valve, said parts cooperating so that when the valve is suddenly opened, a portion of the ^ ~~quantity of~~ gas under pressure will pass into the well and thereby raise the static pressure in the well head, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, a microphone connected with the well, an indicating device electrically connected with the microphone, and an amplifier between the microphone and the indicating device cooperating to indicate the elapsed time for the wave to traverse the space to the well bottom.

Signed at Los Angeles, Calif. this 27th day of Oct., 1933.

Inventor sign full name:

HAROLD T. WYATT
PAUL E. LEHR

OATH

State of California
County of Los Angeles—ss.

Paul E. Lehr and Harold T. Wyatt, the above named petitioners, being duly sworn, depose and say that they are citizens of the United States, and residents of Long Beach, California; that they verily believe themselves to be the original, first and

Defendant's Exhibit U—(Continued)

joint inventors or discoverers of the Method and Apparatus for Measuring Well Depths described and claimed in the annexed specifications; that they do not know and do not believe that the same was ever known or used before their invention or discovery thereof, or patented or described in any printed publication in any country before their invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this application; that said invention has not been patented in any country foreign to the United States on an application filed by them or their legal representatives or assigns more than twelve months prior to this application; and that no application for patent on said invention has been filed by them or their legal representatives or assigns in any country foreign to the United States.

Inventor sign full name:

HAROLD T. WYATT

PAUL E. LEHR

Subscribed and sworn to before me, this 27th day of October, 1933.

(Seal) H. S. ST. CLAIR

Notary Public in and for the County of Los Angeles, State of California.

My Commission Expires March 20, 1935.

V-3526 696290 1564

974

Print of drawing as originally filed.

Fig 1.

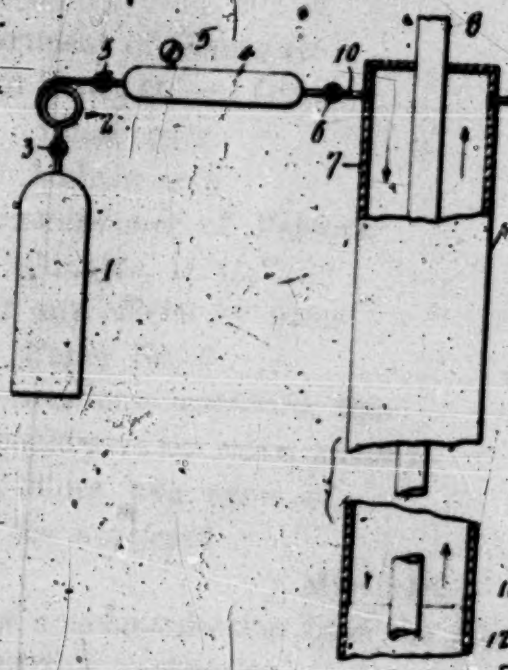
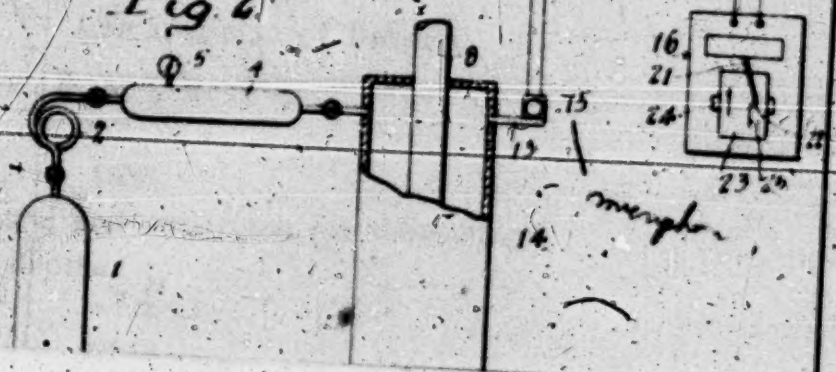
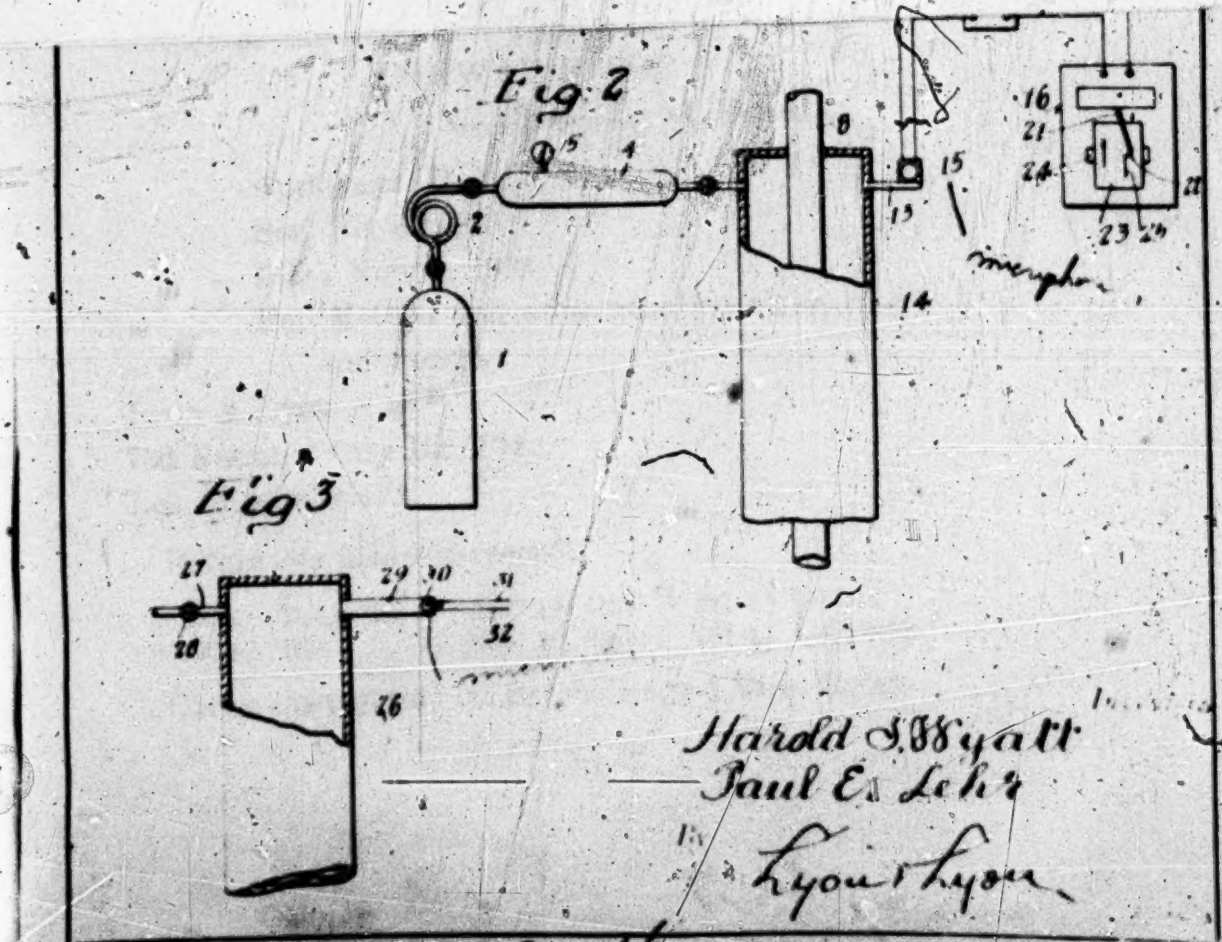


Fig 4

Fig 2.





42 696290 16

Defendant's Exhibit U—(Continued)

260

Div. 42 Room 5882

Department of Commerce
United States Patent Office
Washington
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name
Paper No. 3
All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Mar 8 1934

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE
Commissioner of Patents.

Applicant: P. E. Lehr et al
Ser. No. 696,290
Filed Nov. 1, 1933
For Method and apparatus for measuring
well depths

Lyon & Lyon
708 National City Bk. Bldg.
Los Angeles, Calif.

References made of record:

602,422	Batcheller	Apr. 19, 1898	181-0.5 (386.1x
1,889,614	Rice	Nov. 29, 1932	181-0.5 (352.5x.52

Claim 1 is rejected on Batcheller and Rice. Batch-

Defendant's Exhibit U—(Continued)

eller produces an impulse wave by suddenly producing a pressure. It would not be invention in Batcheller to produce the impulse wave by a sudden release of pressure in view of the disclosure of Rice.

Claim 2 is rejected as alternative since it is drawn to the modification of Figs. 1 or 2 or the modification of Fig. 3.

Since the generic claims are unpatentable division is required between:

I—claims 3 and 5 through 10 drawn to the modification of Figs. 1 or 2 and

II—claim 4, drawn to the modification of Fig. 3.

Should applicant insist upon the patentability of any generic claims either as now presented or in different form, the response, to be complete, must include an election of the species it is desired to retain in the event that generic claims are not finally found to be allowable. (Ex parte Doane, 410 O. G. 275).

H. O. CUTTING
Examiner

LCL
lcl;v

Defendant's Exhibit U—(Continued)

Mail Division Aug 20-34 U. S. Patent Office. Division 42, Paper No. 4. Aug 21 1934 U. S. Patent Office.

In the United States Patent Office
Division 42—Room 5882

In re application of
Paul E. Lehr, et al,

METHOD AND APPARATUS FOR MEASURING WELL DEPTHS,

Serial No. 696,290,
Filed November 1, 1933.

Los Angeles, California,
August 15, 1934.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Replying to the Examiner's letter of March 8, 1934, amendment is hereby made as follows:

Page 4, line 10, after "sudden" insert —liberation of a sufficient quantity of gas at the well mouth to cause a sudden substantial—; same page, line 11, after "pressure" and before the comma, insert —within the well head—; same page, line 13, strike out "an" and substitute —this produces a pressure—; same page, line 14, strike out "originates".

Claim 1, line 3, strike out "in confining a" and substitute —maintaining a confined—; line 4, before "quantity" insert —sufficient—; line 5, after the comma, insert —to cause a substantial change in the pressure at the local point—; line 6, strike

Defendant's Exhibit U—(Continued)

out "an" and substitute —a pressure—; same line, after "medium" and before the comma, insert —due to the difference of pressure—.

Claim 2, lines 2 and 3, strike out "in confining gas" and substitute —maintaining a confined supply of gas under pressure—; same claim, line 3, place a comma after "mouth"; line 4, before "gas" insert —said—; same claim and line, strike out "into or out of" and substitude —at—; line 5, before "an" insert —a substantial change in pressure and—.

Claim 3, line 2, after "in" insert —maintaining a confined supply of gas under pressure at the well head,—; line 3, before "gas" insert —the said—; line 4, before "an" insert —a substantial change in pressure and—.

REMARKS

The references cited by the Examiner have been carefully studied. The patent to Batcheller seems to applicant to be the only one of any importance on the question of novelty, and this patent employs an entirely different idea of means for attaining applicants' result. Before filing this application, applicants were quite familiar with the Batcheller method, but in using it in actual practice in making well tests, it was not found satisfactory for the reason that there is not enough energy in the sound waves produced, to enable them to give satisfactory results in deep wells, and particularly in crooked wells, because there is so much reflection of the

Defendant's Exhibit U—(Continued)

sound by the walls of the well. Furthermore, the firing of an explosive material such as gun powder into the head of an oil well, is accompanied by considerable risks from fire. Applicants' method and apparatus operate on an entirely different principle, and they do not employ sound waves for attaining the result. In applicants' method they maintain a supply of gas under pressure, either in the well head, or adjacent the well head, and then they suddenly liberate a sufficient quantity of gas under pressure, either into the well head, or out of it, to cause a substantial change in pressure within the well head. This causes an impulse wave (not a sound wave) that passes down to the bottom of the well, and is reflected back again. This invention can be practiced without any danger whatever, of fire, and has been found in practice to give very satisfactory results.

While applicants consider that all of the claims, as last presented, are clearly allowable, nevertheless, it seemed advisable to make some amendments in Claims 1 to 3, so as to prevent any possibility of these claims reading in terms on the Batcheller method. In connection with the amendments to these claims, the Examiner should note that these claims refer to maintaining a confined supply of gas under pressure. Batcheller does not do this. He merely makes a noise at the mouth of the well by means of a firearm. Batcheller's method is based on making a loud noise, and while a small quantity of gas from the explosion is admitted into the well head,

Defendant's Exhibit U—(Continued)

this gas is of relatively small quantity, and does not, as in applicants' method, substantially change the static pressure within the well head.

For these reasons the claims as now amended, are considered clearly allowable.

Claim 2 has been amended to overcome the objection which the Examiner made.

In view of the wording of the amended claims, aplicants still consider that generic claims covering both forms of the invention, are patentable to applicants. For this reason no division in the application has been made, and the Examiner is requested to withdraw his requirement as to this. However, for the Examiner's information, applicant now elects the embodiment of the invention as covered by the claims, which do not include Claim 4.

The patent to Rice does not appear to applicants to be even relevant. It is true that it does involve the idea of reflecting a sound to an airplane from the earth, but it does not involve a method in which a supply of gas under pressure, is maintained at a well head, and this pressure changed suddenly so as to produce a pressure wave.

In view of these explanations and amendments, the Examiner is now requested to pass the application to formal allowance.

Respectfully submitted,

LYON & LYON

Attorneys for Applicant

FDA:LM

Defendant's Exhibit U—(Continued)

260

Div. 42 Room 5882

"Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name.

Paper No. 5

All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Department of Commerce
United States Patent Office
Washington

Dec 14 1934

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE
Commissioner of Patents.

Lyon and Lyon
708 National City Bank Bldg.
Los Angeles, Calif.

Applicant: P. E. Lehr et al
Ser. No. 696,290
Filed Nov. 1, 1933
For Method and apparatus for measuring well depth.

Responsive to amendment filed Aug. 20, 1934.

Upon careful reconsideration claim 1 is rejected as clearly met by Rice. In this reference the valve 8

Defendant's Exhibit U—(Continued)

suddenly liberates a sufficient quantity of confined fluid at the local point to cause a substantial change in the pressure at the local point. This produces a pressure impulse wave in said medium due to the difference in pressure. The other steps in the claim are clearly present in the disclosure of the reference.

Claims 2, 3 and 5 thru 10 are rejected on Batcheller and Rice for reasons given in the last office letter in the rejection of claim 1. The distinction between a sound wave and a pressure impulse is not apparent. A sound wave is nothing more than a pressure impulse wave. It is obvious that Batcheller utilizes the same type of wave that the applicant does irrespective of what he calls it. The wave of Batcheller is produced by the sudden liberation of a quantity of gas.

Since the generic claims are still believed to be unpatentable an action on the merits of claim 4 is not given at this time.

H. MARAA
Acting Examiner

L.C.L.
lcl;v

Defendant's Exhibit U—(Continued)

Application Div. U. S. Patent Office. Jun 12 35.

Division 42, Paper No. 6. Jun 13 1935. U.S. Patent Office.

In the United States Patent Office
Division 42—Room 5882

In re application of
Paul E. Lehr, et al,
Method and Apparatus for Measuring Well Depths,
Serial No. 696,290,
Filed November 1, 1933.

Los Angeles, California,
June 4, 1935.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Replying to the Examiner's letter of December 14, 1934, amendment is hereby made as follows:

Page 4, line 11, before "pressure" insert —static —.

Cancel Claim 1, and substitute the following claim to take its place:

B1

~~11. A method of measuring the distance from a~~ local point to the surface of a distant object through a fluid medium which consists in maintaining a confined supply of fluid under pressure, suddenly liberating a sufficient quantity of the confined fluid at the local point, to cause a substantial change in the static pressure at the local point and thereby producing a ~~pressure impulse wave in said medium due to the~~

Defendant's Exhibit U—(Continued)

~~change of pressure, and observing the elapsed time~~ for the impulse wave to traverse ~~the~~ space between the local point ~~and~~ the object and return to the local ~~point.—~~

Cancel Claim 2 and substitute the following claim to take its place:

B2

9 ~~12~~. A method of measuring the distance to an obstruction or liquid in a well, which consists in maintaining a confined supply of gas under pressure at the well's mouth, suddenly liberating a quantity of the said gas under pressure at the well mouth and thereby producing a substantial change in static pressure and an impulse wave in the gas in the well, and observing the elapsed time for the impulse wave to traverse the space from the head of the well to the obstruction, and back again to the well's mouth.

Claim 3, ~~line~~ 2, strike out the matter inserted by amendment heretofore in this line, and substitute the following therefor:

B3

—maintaining a confined supply of gas under pressure at the well head on the exterior of the casing,— same claim, line 4, strike out the matter inserted in this line heretofore, and substitute the following therefor: —a substantial change in static pressure and—.

Claim 4, line 3, before "gas" insert —quantity of—; line 4, after "thereby" insert —suddenly re-

Defendant's Exhibit U—(Continued).

ducing the static pressure in the casing head and—; same claim, line 5, place a comma after "casing".

Claim 5, line 2, strike out "for"; line 3, after "gas" insert —maintained—; line 4, change "interior" to —head—; line 7, strike out "quantity of gas" and substitute —portion of the gas—; line 8, after "thereby" insert —raise the static pressure of the gas at the head of the well to—; line 12, place a comma after "head"; strike out "and" and substitute —thereby—; same claim, line 13, strike out all of this line except the comma, and substitute —during the wave's travel—.

Claim 6, line 2, strike out "for"; line 4, change "interior" to —head—; line 8, strike out "quantity of" and substitute —portion of the—; line 9, after "thereby" insert —cause an increase of static pressure in the gas in the well head, and—; same claim, strike out the last line and substitute —and return—.

Claim 7, line 3, strike out "for"; line 5, change "interior" to —head—; line 7, strike out "quantity of" and substitute —portion of the—; line 8, after "thereby" insert —cause a rise in the static pressure in the well head, and—; last line, strike out "back again" and substitute —return—.

Claim 8, line 3, strike out "for"; lines 6 and 7, strike out "quantity of" and substitute —portion of the—; line 8, after "thereby" insert —cause a rise in the well head static pressure, and—.

Claim 9, line 3, strike out "for"; line 6, strike out "quantity of" and substitute —portion of the—;

Defendant's Exhibit U—(Continued)

same claim, line 7, after "thereby" insert —raise the static pressure in the well head, and—.

Claim 10, line 3, strike out "for"; line 6, strike out "quantity of" and substitute —portion of the; same claim, line 7, after "thereby" insert —raise the static pressure in the well head, and—.

REMARKS

The references cited by the Examiner have been carefully restudied. In view of the importance of this invention, a personal interview with the Examiner by associate counsel is requested, as it is believed that such an interview should save time in advancing the application toward allowance.

Applicant considers that a sound wave is not merely a pressure impulse wave. A sound wave is a series of compressions and rarefractions. Furthermore, a sound wave has very little energy. It is pointed out in applicants' specification at the time of filing this application, that sound waves have been found to be unsatisfactory for determining the depth of deep wells, due to the fact that sound waves have so little energy. In this connection the Examiner is reminded that deep wells are not straight, and a sound wave descending in a well is subject to many reflections during which a large part of the energy of the wave is absorbed. In both of the references cited, a sound wave is employed for determing the distance to the surface on which the wave is reflected. Applicants' method and apparatus involves a different idea of means for accomplishing that re-

Defendant's Exhibit U—(Continued)

sult. In accordance with applicants' method, there is an actual sudden raising or lowering of the static pressure in the well head, and applicants' method is readily controllable so as to vary the change of pressure at the well head to correspond with the energy required to determine the depth of the well, whatever that depth may be. The Batcheller method of discharging a revolver in the casing is objectionable because it increases a fire hazard; and furthermore, it does not develop a sound wave of sufficient energy to insure effective results in a very deep well, and particularly a crooked well.

Furthermore, applicants' attorneys do not consider that the claims can be read fairly on the Batcheller construction or method. However, in order to enable the claims to distinguish even more clearly, they have been amended to bring out the fact that in applicants' method and apparatus, a portion only of the confined gas is released either into the casing or out of the casing. Applicants' attorneys do not consider that the revolver shown in the Batcheller patent is a means for maintaining a supply of confined gas. It is a means for suddenly generating a sound. And applicants' attorneys object to the use of this revolver as the equivalent of means for maintaining a supply of gas at the well head. It is believed, however, that by reason of the amendments made above, the claims distinguish very clearly from this reference, and also from the reference Rice. In the Rice patent, the operation of the apparatus depends upon the generating of a sound at the air-

Defendant's Exhibit U—(Continued)

plane, and involves the necessity for employing a special receiving apparatus in which all sounds are tuned out except the desired sound which is generated to be reflected by the earth below the plane. This is certainly an idea of means totally different from those employed by the applicants. There is no generation of a pressure wave that raises the static pressure. The apparatus shown by Rice is not considered in any sense the equivalent of applicants' apparatus. It operates on a different principle, and is a complicated apparatus involving the use of selective sound reducing apparatus. Applicants' attorneys consider that the rejection of the claims on these references is very far fetched, and in this connection the Examiner is reminded that one means is not the equivalent of another means unless it operates in the same way to attain the same result. Applicants means is radically different from either of the means used by Batcheller or Rice, and applicants have invented a very simple apparatus and method, which will operate very effectively for measuring well depths. The Examiner is reminded that the patent law is intended to foster the making of improvements such as this, which use simpler means for attaining improved results over the results that have already been attained by prior inventors.

Although applicants' attorneys consider that the means employed by applicants is a radically different means from that disclosed in the references, attention is called to Aeolian Co. vs. Cunningham Piano Co., 251 F. 301, (affirmed in 255 F. 897). The

Defendant's Exhibit U—(Continued)

lower Court used the following language quoted from page 301 of Vol. 251 of the Federal Reporter:

> "Whenever a new thought of real value is thus brought into combination with some means by which the thought is given physical expression, the combination is patentable, although the means may by itself show limited novelty, or even be such as that by itself it would not be patentable. This principle is well established, and we do not understand it to be in dispute. A reference to the cited case of Miehle v. Whitelock, 223 Fed. 647, 139 C.C.A. 201, is a sufficient confirmation of it."

In connection with the case just cited, it will be noted that the effect of the invention is more important than the means actually employed if a new or improved result is attained, as it is in the present case. For the Examiner's convenience, the case just cited will be found in Underwood's Cards 3660-M, Card 154.

Attention is also called to Beldam vs. Garlock Packing Co., 29 F. (2d) 673; 384 O.G. 247, which held that:

> "We must always bear in mind that patented devices are different in the sense of the patent law when they perform different functions, or in a different way, produce a substantially different result."

Referring again to the patent to Rice, it may be true that the Rice apparatus involves the liberation

Defendant's Exhibit U—(Continued)

of a confined fluid at the local point. But the function of the liberating of this fluid is to produce a sound, and it is the sound wave that is employed to determine the distance from the earth. There is no substantial increase in static pressure at the local point, except just at the nozzle where the confined fluid is liberated. There is no wave developed by the static pressure except a sound wave, and the sound wave is the only one that can be employed by the Rice apparatus, involving as it does, a complicated sound receiving apparatus that tunes out all sounds except the desired sound.

The Examiner's attention is also called to a recent case, Gordon Form Lathe Co. vs. Walcott Machine Co., 32 F. (2d) 55, which held that:

> "Patents cannot be considered as anticipations, which do not disclose purpose, means, and mechanism for accomplishing the end of the patent in suit, and which are restricted to a substantially different and limited purpose."

This case is also cited in Underwood's Cards 3660-D, Card 155, and at 17 Pat. Q. 60.

Attention is also called to Wach vs. Coe, Commissioner of Patents, 453 O. G., 463, holding that a combination of old elements with a new mode of operation, is patentable. As pointed out above, the mode of operation of applicants' method and apparatus is radically different from that of the references involving the employment of a simple static pressure wave operating without making of any

Defendant's Exhibit U—(Continued)

sound, or relying upon a weak sound wave for its success.

In view of the above amendments and these explanations, a formal allowance of this application is now respectfully requested.

Respectfully submitted,
LYON & LYON,
Attorneys for Applicants.

_____,
Associate Counsel.

FDA:LM

_____

Commissioner of Patents.
260

Div. 42 Room 5882

Department of Commerce
United States Patent Office
Washington

Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name
Paper No. 7
All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Defendant's Exhibit U—(Continued)

Aug 20 1935.

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE,

Lyon and Lyon
708 National City Bk. Bldg.
Los Angeles, Calif.

Applicant: P. E. Lehr et al
Ser. No. 696,290
Filed Nov. 1, 1933
For Method and apparatus for measuring well depts

Responsive to amendment filed June 12, 1935.

In the drawings the following elements should bear legends such as those indicated, element 1 "source of fluid pressure", element 6 "quick acting valve", element 9 "outlet", elements 15 and 30 "microphone", element 18 "amplifier", element 16 "recorder". These requirements are in accord with ex parte Good 164 O. G. 739 which brings out that the drawings wherever possible should be so complete as to tell the story in the absence of the specification.

Page 7, line 22, "13" should be —15—.

Page 8, line 22, page 9, line 2, "micrometer" is incorrect.

Claims 3 thru 10 and 12 are allowable as at present advised.

Claim 11 is rejected as broader than the invention. The applicant has not shown that the matter

Defendant's Exhibit U—(Continued)

claimed could be used to measure distance in space. In fact he has not shown that it can be used to measure a distance other than the distance to an obstruction in a tube. In the absence of such a showing the claim is clearly broader than the invention for reasons set forth in ex parte Langmuir, 10, Pat. Q. 113 ex parte Opdyke 1890 C. D. 39, ex parte Aram 1926 C. D. 47 and ex parte Tabb 1926 C. D. 107.

Prompt response is urged in view of the condition of the case.

H. O. CUTTING,
Examiner.

LCL
lcl:v

Paper No. 8

Mail Division Sep 23 1935 U. S. Patent Office.

In the United States Patent Office
Division 42—Room 5882

In re application of
Paul E. Lehr, et al,
Serial No. 696,290,
Method and Apparatus for
Measuring Well Depths,
Filed November 1, 1933.

Defendant's Exhibit U—(Continued)

Los Angeles, California,
September 17, 1935.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Please amend the drawing in the above-entitled case, by adding legends to the different parts as indicated in the print of the drawing filed herewith. Add reference numeral to Fig. 4 as shown in the print.

Remarks

If there is any charge for adding these legends to the drawing, please charge the same to the Miscellaneous Fees account of Lyon & Lyon.

Respectfully submitted,
LYON & LYON,
Attorneys for Applicant.

Approved Sept 24, 1935 LCL.
Received in Div. C Sep 26 1935.
Correction Ordered Oct. - 3 1935 Account.
Div C Corrected Oct - 3 1935.
Print Returned by Drafting Div.
FDA:LM

Paper No. 9
Mail Division Sep 23 1935 U. S. Patent Office.
In the United States Patent Office
Division 42—Room 5882

Defendant's Exhibit U—(Continued)

In re application of
Paul E. Lehr, et al,
Serial No. 696,290,
Method and Apparatus for
Measuring Well Depths,
Filed November 1, 1933.

Los Angeles, California,
September 17, 1935.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Replying to the Examiner's letter of August 20, 1935, amendment is hereby made as follows:

Page 7, line 22, change "13" to —15—.

Page 8, line 22, strike out "michrometer" and substitute —microphone—.

Cancel Claim 11.

Remarks

Claim 11 has been canceled, and an amendment to the drawing is filed herewith, and as soon as the drawing has been corrected in accordance with the amendment, this application should be in condition for formal allowance.

The corrections in the specification suggested by the Examiner have been made.

Respectfully submitted,
LYON & LYON,
Attorneys for Applicant.

FDA:LM

Defendant's Exhibit U—(Continued)

[Printed in Margin]: In Remitting the Final Fee Give the Serial Number at the Head of This Notice.

[Printed in Margin]: Uncertified Checks Will Not Be Accepted.

Serial No. 696,290.

42-5882

Address Only

The Commissioner of Patents

Washington, D. C.

Department of Commerce

United States Patent Office

Washington October Thirty, 1935.

Paul E. Lehr and Harold T. Wyatt

Your Application for a patent for an Improvement in Method and Apparatus for Measuring Well Depths filed Nov. 1, 1933 has been examined and Allowed with 9 claims.

The final fee, Thirty Dollars, with $1 Additional for Each Claim Allowed in Excess of 20, must be paid not later than Six Months from the date of this present notice of allowance. If the final fee be not paid within that period, the patent will be withheld, but the application may be renewed within one year after the date of the original notice with a renewal fee of $30 and $1 additional for each claim in excess of 20.

The office delivers patents upon the day of their date, on which date their term begins to run. The preparation of the patent for final signing and sealing will require about four weeks, and such work

Defendant's Exhibit U—(Continued)

will not be begun until after payment of the necessary final fee.

When the final fee is paid, there should also be sent, Distinctly and Plainly Written, the name of the Inventor, Title of the Invention, and Serial Number as Above Given; Date of Allowance (which is the date of this circular), Date of Filing, and, if assigned, the Names of the Assignees.

If it is desired to have the patent issue to an Assignee or Assignees, an assignment containing a Request to that effect, together with the Fee for recording the same, must be filed in this office on or before the date of payment of the final fee.

After issue of the patent, uncertified copies of the drawings and specifications may be purchased at the price of Ten Cents Each. The money should accompany the order. Postage stamps will not be received.

The final fee will Not be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

Notice.—When the Number of Claims Allowed Is in Excess of 20, No Sum Less than $30 Plus $1 Additional for Each Claim in Excess of Twenty Can Be Accepted as the Final Fee.

Respectfully,

CONWAY P. COE,

Commissioner of Patents.

Lyon and Lyon
708 National City Bk. Bldg.
Los Angeles, Calif.

Defendant's Exhibit U—(Continued)

Attorney's Room Jan 27 1936 U. S. Patent Office.

Issued Oct. 30, 1935.

U. S. Patent Office Jan 29 1936 Issue Division.

In the United States Patent Office

Paper No. 10

In re application of
Harold T. Wyatt and
Paul E. Lehr,
Method and Apparatus for
Measuring Well Depths,
Serial No. 696,290,
Filed November 1, 1933.

POWER TO INSPECT THE FILE

Los Angeles, California,
January 22, 1936.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Please permit Bernard J. Gratama, Register No. 12,728, to inspect the file of the above indicated application at any time, and to make copies of the papers in said file or any part thereof.

Respectfully submitted,
LYON & LYON,
Attorneys for Harold T. Wyatt and Paul E. Lehr.

Defendant's Exhibit U—(Continued)

Apr. 24, 36 198432 E 2 Check—30.00

35/238

Telephone
MIchigan 3901
Law Offices
Lyon & Lyon
Patent and Trademark Causes
811 West Seventh Street
Los Angeles

April 20, 1936.

[Pencil Notation]: Suspend

Mail Division Apr 24 1936 U. S. Patent Office.

Frederick S. Lyon
Leonard S. Lyon
Lewis E. Lyon
Richard F. Lyon

Henry S. Richmond
Irwin L. Fuller
Reginald E. Caughey
Casimir A. Miketta
Harold W. Mattingly

Francis D. Ammen
William A. Doble, Jr.
Eugene Woodbury

Commissioner of Patents
Washington, D. C.

Sir:

Attached is our check No. 6756 in the amount of $30.00 which please apply to payment of the final Government fee in the United States patent appli-

Defendant's Exhibit U—(Continued)

cation of Paul E. Lehr and Harold T. Wyatt, Serial No. 696290, filed November 1, 1933 for Method and Apparatus for Measuring Well Depths, which was allowed October 30, 1935 with 9 claims.

It is respectfully requested that issue of the patent be deferred for a period of Ninety (90) days.

Respectfully,

LYON & LYON.

Kindly Note Change of Our Address to 811 West Seventh Street Building, Los Angeles.

July 21/36.

LP

Enc

Address Only

The Commissioner of Patents

Washington, D. C.

Department of Commerce

United States Patent Office

Washington

April 27, 1936

Lyon & Lyon

811 West Seventh Street Bldg.,

Los Angeles, California

Applicant Lehr, Paul E. & Wyatt, Harold T.

Serial No. 696290

Filed November 1, 1933

For Method and apparatus for measuring well depths.

Final Fee April 24, 1936

Issue Date July 21, 1936

Defendant's Exhibit U—(Continued)

Sir:

Your letter requesting deferment under Section 4885 R. S. has been received.

Respectfully,

J. A. BREARLEY,

J. A. Brearley,

Chief Clerk JL

DHC

[Printer's Note: Copy of Patent No. 2,047,974, issued to P. E. Lehr et al, for "Method and Apparatus for Measuring Well Depths," attached here, is not reproduced, as it is set out in full as Plaintiffs' Exhibit No. 18, in this Book of Exhibits.]

421

1933

Contents:

1. Application.....papers.
2. Print Nov. 6, 1933.
3. Rejection Mar 8 1934.
4. Amdt. A Aug. 20, 1934.
5. Rejection Dec 14 1934.
6. Amdt B June 12 1935
7. Rejection Aug 20 1935.
8. Letter to Dfs. Sept. 23, 1935.
9. Amdt. C Sept. 23, 1935
10. Power to Inspect Jan. 27, 1936.

[Endorsed]: Filed Nov. 10, 1942.

CLERK'S COPY.

Vol. VI

TRANSCRIPT OF RECORD

(Pages 1593 to 1618)

Supreme Court of the United States

OCTOBER TERM, 1945

No. ~~290~~ 24

HALLIBURTON OIL WELL CEMENTING COMPANY, PETITIONER,

vs.

CRANFORD P. WALKER AND CRANFORD P. WALKER, D. A. WALKER, ET AL., DOING BUSINESS AS DEPTHOGRAPH COMPANY, COPARTNERSHIP

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT

PETITION FOR CERTIORARI FILED AUGUST 2, 1945.

CERTIORARI GRANTED OCTOBER 15, 1945.

No. 10513

IN THE

United States Circuit Court of Appeals

For the Ninth Circuit

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Appellant,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER, and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Appellees.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER, and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Appellants,

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Appellee.

Upon Appeals from the District Court of the United States for the Southern District of California, Central Division

---

PROCEEDINGS HAD IN THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT

United States Circuit Court of Appeals
for the Ninth Circuit

Excerpt from Proceedings of Wednesday, March 29, 1944.

Before: Denman, Stephens and Healy,
Circuit Judges.

[Title of Cause.]

ORDER OF SUBMISSION

Ordered appeals herein argued by **Mr. Earl Babcock**, counsel for Halliburton Oil Well Cementing Company, and by Mr. Harold Mattingly, counsel for Walker, et al., and submitted to the Court for consideration and decision.

United States Circuit Court of Appeals
for the Ninth Circuit

Excerpt from Proceedings of Thursday, December 28, 1944.

Before: Denman, Stephens and Healy,
Circuit Judges.

ORDER DIRECTING FILING OF OPINION AND FILING AND RECORDING OF DECREE

By direction of the Court, Ordered that the typewritten opinion this day rendered by this Court in above cause be forthwith filed by the clerk, and that a decree be filed and recorded in the minutes of this court in accordance with the opinion rendered.

[Title of Circuit Court of Appeals and Cause.]

Upon Appeals from the District Court of the United States for the Southern District of California, Central Division

Before: Denman, Stephens, and Healy, Circuit Judges

Healy, Circuit Judge

OPINION

Involved here are cross appeals from a decree in an infringement suit. The court held valid and infringed two patents of Walker, these being No. 2,156,519 and reissue No. 21,383. It adjudged invalid Walker's patent No. 2,209,944.

For convenience we shall refer to the adverse parties as Walker and Halliburton, Walker being the plaintiff. The several patents will be discussed in turn.

Patent No. 2,156,519.[1] The object of this invention is to measure the location of obstructions in oil wells, with particular reference to apparatus for determining the location below the well head of the fluid surface, or the location of tools, pipe sections or couplings which constrict the well bore. The patent is avowedly an improvement on a prior invention covered by Patent No. 2,074,974 issued to Lehr and Wyatt, July 21, 1936. The latter is both a method and an apparatus patent. Some discussion of its nature is essential to an understanding of the character and extent of the refinements thereon claimed by Walker.

---

[1] Applied for Sept. 7, 1937; issued May 2, 1939.

The Lehr and Wyatt patent has as its object the ascertaining of the distance from the well head to the fluid surface.[2] It employs what is called the "impulse wave" principle, which consists in generating a wave by causing a sudden change in pressure at the well head. A quick-opening valve releases gas into the well and the impulse, moving with the sped of sound, travels down the well until it reaches the fluid surface from which point it returns after the manner of an echo. According to the specifications, the total elapsed time between the release of the impulse wave and its return may be observed or indicated "in any desired manner," it being said that the puff may be felt with the bare hand and the elapsed time measured with a stop watch. The inventors suggested the employment of a recording system such as a microphone, an amplifier, and an indicating or recording device, but they did not specify or claim any system of recording.

A difficulty with the Lehr and Wyatt method lies in the variations in the velocity at which the impulse wave travels down and back. An elaborate formula is given for computing the velocity so as to take into account the temperature and pressure of the gas in the well; but the formula is not very accurate since it makes no allowance for variations of temperature and pressure in different parts of the well.

---

[2] This, of course, can be done mechanically, but the doing of it usually entailed the removal from the well of tools, pumping apparatus, etc.

Among the stated objects of the Walker patent now under discussion are included several not mentioned by Lehr and Wyatt. These have to do with the location of obstructions in the well other than the fluid surface; the providing of a recording system which is specified and claimed; and the measurement of the velocity of the impulse wave by checking its elapsed time against that of an echo received from some obstruction the location of which (that is, its distance from the well head) is exactly known. Walker points out that one may determine the velocity of the impulse by timing the interval between its release and the return of the echo from, for example, the tubing catcher, the location of which happens to be known. Given the distance and the time, the velocity may be determined with great accuracy. The process obviates the employment of formulas and the necessity of making corrections for variations of pressure and temperature within the well. The success of the system depends upon the operator's obtaining an identifiable echo from an obstruction of known location, that is, an echo which may be differentiated from the echo sent back by the fluid surface or other obstruction the location of which is not known but which it is desired to determine.

Walker provides a recording apparatus and describes it in much detail. The apparatus or system claimed is old, as indeed are all the other elements of his combination. For present purposes the recording apparatus need not be described fur-

ther than to say it utilizes a diaphragm, a mirror, a light beam, and a strip of film which moves along in the manner of a recording barometer. Peaks of varying amplitude will be shown on the record, each representing an echo.

We are chiefly concerned here with the step precedent to that of recording. It will be appreciated that in the typical oil well there is a plurality of obstructions, each capable of receiving and reflecting a pressure wave. These include the fluid surface, the collars of the sections of the tubing string through which the oil is brought to the surface, and what is termed the tubing catcher. Walker provides a means of amplifying those echoes desired to be recorded and of damping or filtering out those not desired to be recorded.

There are 17 claims. Claims 1 and 14, being among those in suit, are typical. These are as follows:

"1. In an apparatus for determining the location of an obstruction in a well having therein a string of assembled tubing sections interconnected with each other by coupling collars, means communicating with said well for creating a pressure impulse in said well, echo receiving means including a pressure responsive device exposed to said well for receiving pressure impulses from the well and for measuring the lapse of time betwen the creation of the impulse and the arrival of said receiving means of the echo from said obstruction, and means associated with said pressure responsive device for tuning said receiving means to the fre-

quency of echoes from the tubing collars of said tubing sections to clearly distinguish the echoes from said couplings from each other."

"14. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from couplings and other obstructions in said well, pressure responsive echo receiving and registering means coupled to said well to expose said receiving and registering means to pressure variations in said well produced by echoes from said obstructions, and interference eliminating means associated with said receiving and registering means for limiting the response of said receiving and registering means to the registration of echoes from actual obstructions in the well whereby the registered echoes of the tubing couplings may be readily distinguished from each other and from the echoes from other actual obstructions in the well."

The means provided by Walker for amplifying those vibrations desired to be shown as peaks on the chart, and of damping out those not desired to be recorded, is an adjustable tuning pipe, that is, one that may be adjusted by lengthening or shortening it. As is well known, the length of the pipe determines the frequency of the vibrations and the diameter determines their amplitude. The operator of the apparatus watches the echoes as they are

thrown in the form of wavy peaks on the ground-glass screen of the recording device, and adjusts the pipe until he has it of such length that it amplifies the harmonics from the tubing collar echoes while at the same time damping out the peaks caused by echoes of different frequencies.

The trial court found that the only part of this patent constituting invention over the prior art is the "tuned acustical means which performs the functions of a sound filter." It will be noted that Walker's acoustical tuned resonator is a purely mechanical device.

Halliburton, in its allegedly infringing device, employs an electrical filter. The court found that this electrical filter is the equivalent of the acoustical tuned resonator of Walker, and that when the electrical filter is used by Halliburton its apparatus infringes claims 1, 13, 14, 15 and 17 of the patent in suit. Halliburton contests the validity of the Walker patent and denies infringement.

Walker made a very substantial improvement over Lehr and Wyatt, notwithstanding it is conceded that both his recorder and his amplifier, considered by themselves, are old in the art. We think the patentee displayed a measure of inventive genius entitling him to patent protection. He has combined features which achieve a new result, or at least an old result in a better way. Cf Bates v. Coe, 98 U. S. 31, 39; Walker on Patents (Deller's Ed.) Vol. 1, p. 255, and cases there cited. While Lehr and Wyatt suggest an amplifier, they neither sug-

gest nor claim any device which would enable the operator to tune up certain desirable echoes while tuning out undesirable ones. The utility of this feature of Walker's patent is not denied.

Other prior patents cited by Halliburton, as for example the patent of Tucker, No. 1,351,356, which was to aid in locating the source of gunfire, were not designed to perform the same function as Walker's tuning device, and would not, without the addition of other elements, serve the purposes of the Walker patent. The Tucker patent mentioned was among the examples of the prior art cited by the examiner. We think, too, that Walker specified and claimed his improvements with sufficient distinctness and clarity to comply with the statute.

We turn now to the question of infringement. Halliburton's device is called the "Echo-Meter Field Manual." Briefly, the echo-meter consists of a Y-pipe into which a gun is fired to create an acoustical wave, which is the pressure impulse. The wave goes down the well and upon its return enters the other branch of the Y, where it impinges upon a microphone which changes the pressure variations into variations of electrical current. This current is of sufficient strength to move a pen-and-ink recorder over a tape, upon which it makes a permanent record consisting of wavy lines the peaks of which indicate the echoes from the various obstructions and the fluid level.

Between the microphone and the recorder itself is an electrical system which performs some, at

least, of the filtering and echo-differentiating functions of Walker's acoustical system. It consists first of a hot-wire microphone, which is a grid of fine wire electrically heated. The wire is of a kind which is very responsive to temperature changes. The reflected waves from the tubing collars and the fluid level pass across these wires, and the cooling effect of these slight tremors changes the resistance of the wires markedly. The minute electrical signal caused by the change in resistance is introduced into the input of the amplifier and amplifies the current to a level high enough to operate the recorder. The microphone is most responsive to the low frequency changes in pressure such as are caused by the firing of a blank cartridge. The amplifier not only amplifies the small electrical variations in the circuit, but also suppresses to some extent the high-frequency waves which result from extraneous disturbances not desired to be recorded.

Halliburton's argument of noninfringement is based primarily on the indisputable fact that it uses an electrical apparatus, whereas Walker's is mechanical. Where different means are used to accomplish the same end or to perform the same function, the question of infringement depends upon the mode of operation as well as on the sameness of the result.[3] While identity of result is of course not a sufficient test of infringement, nevertheless an infringing device, generally speaking, is one which

[3] Cf. Walker on Patents (Deller's Ed.) Vol 3, pp. 1745, 1750.

"does the same work in substantially the same way and accomplishes substantially the same result." Walker on Patents (Deller's Ed.) Vol. 3, pp. 1707, 1751. The question is whether Halliburton's device is substantially the equivalent of Walker's.

In a measure the problem here is one of appraising the advance in the art effected by Walker. The generalities of the problem have not been better stated than by the Court in Eibel Co. v. Paper Co., 261 U. S. 45, 63: "In administering the patent law the court first looks into the art to find what the real merit of the alleged discovery or invention is and whether it has advanced the art substantially. If it has done so, then the court is liberal in its construction of the patent to secure to the inventor the reward he deserves. If what he has done works only a slight step forward and that which he says is a discovery is on the border line between mere mechanical change and real invention, then his patent, if sustained, will be given a narrow scope and infringement will be found only in approximate copies of the new device. It is this differing attitude of the courts toward genuine discoveries and slight improvements that reconciles the sometimes apparently conflicting instances of construing specifications and the finding of equivalents in alleged infringements."

A detailed comparison of the mode of operation, function, and result achieved by the respective devices with which we are here concerned would expand this opinion to undue lengths. The over-all picture already attempted is perhaps more helpful

than a piecemeal analysis of the several elements of the combinations. It is certain that there is a substantial identity of function between the two. Both the tuning pipe and the electrical filter have the property of amplifying certain vibrations and eliminating others. The result to be achieved is likewise the same in both cases in that only certain vibrations, which will cause certain peaks to appear on a graph, are permitted to reach the recording apparatus.

The trial court's finding of substantial identity between the tuned acoustical means of Walker and the electrical filter of Halliburton is supported by the testimony of experts. We are not disposed to say that the finding is clearly erroneous. While Halliburton's device is by no means a Chinese copy of Walker's we think the Walker patent is entitled to a liberal construction and to a fair range of equivalents.

Apart from expert testimony, the finding of equivalency appears to have support in statements of the Patent Office Examiner made during the course of repeated rejections of an application of Walker's for an electrical impulse receiving and tuning device. The Examiner referred to No. 2,156,519, which had already issued, saying "The Walker patent discloses means for tuning mechanically to the selected echo, but it is obvious that electrical tuning could be used instead in a system comprising an electrical receiving circuit . . . . The equivalence of electrical tuning and mechanical tuning for selective reception was thought to be so generally

recognized that citation of an illustrative reference was not considered necessary."

Patent No. 2,209,944.[1] The court held this patent invalid for want of invention, finding that its novelty lay only in the performance of certain mental steps.

This is a method patent. The steps involved are described in the claims by the following descriptive words "determining," "registering," "counting," "observing," "measuring," "comparing," "recording," "computing." There are 9 claims, all of which are in suit. Claim 2, copied below, may be taken as typical:

"2. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating an acoustical impulse in the annular space between the tubing and the well casing to produce echoes from portions of the tubing string distinguishable from each other and from the echo from the unknown obstruction, observing the lapse of time between the arrival at a predetermined point of the echoes from successive portions of the tubing string to thereby determine the velocity of the pressure wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction."

In substance, Walker's method here claimed con-

[1]Applied for Sept. 25, 1939; issued July 30, 1940.

sists in setting down three knowns in a simple equation and from them determining or computing an unknown. The three knowns are: (a) the distance from the well head to the tubing catcher (for example); (b) the length of time it takes an echo to return from that obstruction; and (c) the length of time it takes an echo to return from the fluid surface. From these three knowns can then be determined the distance of the fluid surface from the well head.

We think these mental steps, even if novel, are not patentable. Cf. Don Lee, Inc. v. Walker, 9 Cir., 61 F. 2d 58. A patent may be obtained only upon an invention of a "new and useful art, machine, manufacture, or composition of matter." 35 USCA §31. As said in Cochrane v. Deener, 94 U. S. 780, 788: "A process is a mode of treatment of certain materials to produce a given result. It is an act, or a series of acts, performed upon the subject-matter to be transformed and reduced to a different state or thing. If new and useful, it is just as patentable as is a piece of machinery. In the language of the patent law, it is an art." Cf. also Corning v. Burden, 15 How. 252, 267.

It must be remembered that this is purely a method patent. No apparatus is claimed. Given an apparatus for initiating an impulse wave in a well and a means for differentiating between and for recording echoes returned from obstructions in it, anybody with a rudimentary knowledge of arithmetic will be able to do what Walker claims a monopoly

of doing. If his method were patentable it seems to us that the patentee would have a monopoly much broader than would the patentee of a particular apparatus. To sum the matter up, we think Walker's apparatus patent No. 2,156,519 gives him all the protection his inventive genius entitles him to.

Reissue No. 21,383. This is a method patent, held valid and infringed by the trial court. It is a reissue, dated March 5, 1940, of No. 2,161,733 on methods of determining the fluid density, fluid pressure and potential production capacity of oil wells. The claims, of which there are 11, are all in suit. They include five claims on methods for determining the density of the fluid in the standing column, four for determining the pressure at any desired point below the fluid surface while the pump is operating, and two, numbers 8 and 11, for determining the potential production capacity of the well. One claim typical of each group is set out in the footnote.[5] The

[5] "5. The method of determining the density of the standing column of fluid in an oil well having a casing and a mechanical pump suspended therein upon pump tubing and without requiring the removal of pump parts, which consists in the steps of operating the pump under one stable condition of gas pressure in the casing until the fluid level becomes stable, measuring the distance between the casing head and the surface of the fluid under this stable condition, altering the casing pressure to a new condition, operating the pump at the same rate of production under the new condition of gas pressure to again stabilize the fluid level, measuring the distance between the casing head and the new level of the fluid surface under said new stable condition, and measuring the casing head pressures under the

steps involved in carrying out the methods are described, as were those in No. 2,209,944, by descriptive words.

Fluid pressure had previously been determined by methods which required the removal from the well bore of pump and tubing. Walker eliminates this difficulty very simply. He first determines the pressure on the fluid surface, in this fashion: he locates the fluid surface in the manner described by Lehr

---

two stable conditions, whereby the pressure exerted by the fluid per unit of height of the fluid is represented by comparing the difference in height of the fluid surface levels and the difference between the pressures on the fluid surface required to maintain the fluid surface at the two levels."

"7. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted in the standing column of fluid at any desired level below the normal surface of said column while the pump is operating to remove fluid from the well, which comprises measuring the actual stable level of the fluid under one known condition of gas pressure in the well by sonic sounding method, determining the pressure on the fluid surface at that level, changing the pressure of the gas in the well to move the surface of the column to a new actual level, continuing to operate the pump at the same production rate as for the first condition of gas pressure in the well until the fluid level again becomes stable, measuring the new stable level and determining the pressure upon the fluid surface at this new level, determining the pressure exerted per unit of height of the fluid column by dividing the change in gas pressure on the fluid surface required to effect the change in the fluid level by the difference in height of the two levels, and computing the unknown pressure at the desired level by adding to the gas pressure upon the

and Wyatt or by No. 2,156,519; he notes the specific gravity and pressure of the gas at the casing head, and a few simple arithmetical steps and the use of a formula avowedly old in the art then give the pressure on the fluid surface in terms of whatever units of measurement are desired to be used. The operator next determines the fluid density: building up the gas pressure above the fluid surface forces

---

fluid surface at either of the actual levels the effect in pressure of the fluid column between the selected actual level and the desired level."

"11. The method of determining the potential production capacity of a well having a casing and a pump suspended therein, which comprises: determining the pressure exerted by the well fluid at some selected point below the normal surface thereof under one known rate of production, by determining the location of the fluid surface under one condition of gas pressure on the surface, determining the gas pressure on the fluid surface under said one condition, changing the gas pressure to move the fluid surface to a new stable level under the same production rate, determining the new gas pressure on the fluid surface, determining the location of the new surface level, comparing the difference in said gas pressures with the corresponding change in height of the surface level, to thereby ascertain the pressure exerted at said selected point under said one rate of production; changing the rate of production from said well; repeating the steps of determining the location of the fluid surface at two stable levels and the gas pressures on said surface to maintain said levels under the new production rate to ascertain the pressure exerted at the same selected point; and comparing the difference in the production rates with the corresponding difference in pressures at said selected point to determine their relation from which the maximum rate of production from the well may be determined."

down the latter, and the pressure on the new fluid surface is determined in the manner just outlined; the difference between the two pressures is divided by the difference between the two fluid levels, and the quotient is the density of the fluid, that is, the pressure exerted by the fluid per unit of height of the standing column.

The fluid pressure at any point below the fluid surface, as for instance at the pump inlet, may now be found either by plotting the information already obtained on a graph and extrapolating, or by the use of a rather involved, but mathematically elementary, formula.

Potential production capacity is found in this manner: pump inlet pressure is determined when the pump is operating at two different known rates, and the relation between the two rates of production and the two pressures at the inlet gives a constant which indicates that there exists a fixed ratio between pressure and production. This constant is then employed at a theoretical zero pump inlet pressure, and the corresponding production rate will be the maximum for that well. That this must be so will be readily understood, for the oil cannot be pumped out of the well any faster than it flows in, while if it is removed less fast than it flows in from the oil-bearing sands, the flow in must buck the pressure downwards which results from the slower removal of the oil. This determination may also be made graphically, according to the patent.

What we have said about the mental steps detailed No. 2,209,944 applies with equal force to

the steps we have described here. While their compilation may have elements of novelty, we do not think it involves patentable invention.[6] Thus ascertaining the fluid density involves making a preliminary determination (the location of the fluid surface) by a method old in the art, and then making a series of the simplest sort of arithmetical steps based on the assumption, of dubious validity,[7] that the density of the fluid column is constant throughout its height. Pressure below the fluid surface is then found by applying the information already obtained to the performance of other simple computations, aided by the use of formulae old in the art. Finally, finding the potential production capacity

---

[6] Prior art publications by Hawthorn (Subsurface Pressures in Oil Wells and Their Field of Application, 1933) and Vietti (Density of Oil-Gas Columns from Well Data, 1930), among others, deal with the determination of the specific gravity and density of the fluid column. Indeed, Hawthorn describes a method of extrapolating the density curve in order to learn fluid pressure which is very close to the method described in the patent in suit. It seems clear that only the non-existence at the time these articles were written of a good method of locating the fluid surface prevented the authors from working out every step described in No. 21,383, and it will be recalled that it was Lehr and Wyatt, not Walker, who taught how to locate the fluid level.

[7] Walker alleges that he was the first to discover this phenomenon; it is agreed that petroleum engineers had theretofore thought fluid density increased with the distance from the fluid surface. Halliburton controve[illegible] the validity of the alleged discovery, and Walke[illegible]tes no authority except his own observations to prove his thesis.

of the well involves neither formulae nor further observations, but simply a little more elementary arithmetic. In fact, it appears to us that claims 8 and 11 are but statements of the ultimate objects sought to be accomplished by the patent, and summaries of that which had been detailed in the claims having to do with pressure and density.

Walker argues strenuously in defense of this patent that the use of the word 'determining,' the key participle both in this and in the method patent No. 2,209,944, does not limit him to mere arithmetical processes. The difficulty with this argument is that no other method of making the determinations of pressure, density and production capacity is suggested except the graphic one, and it is well understood that a graph may be used to define mathematical formulae and processes as accurately as numbers or symbols.

The judgment, insofar as it adjudges Reissue No. 21,383 valid and infringed, is reversed. In all other respects it is affirmed.

[Endorsed]: Opinion. Filed Dec. 28, 1944. Paul P. O'Brien, Clerk.

United States Circuit Court of Appeals
For the Ninth Circuit

No. 10513

HALLIBURTON OIL WELL CEMENTING CO.,
Appellant,

vs.

CRANFORD P. WALKER, et al.,
Appellees.

CRANFORD P. WALKER, et al.,
Appellants,

vs.

HALLIBURTON OIL WELL CEMENTING CO.,
Appellee.

DECREE

Appeals from the District Court of the United States for the Southern District of California, Central Division.

This cause came on to be heard on the Transcript of the Record from the District Court of the United States for the Southern District of California, Central Division, and was duly submitted.

On Consideration Whereof, it is now here ordered, adjudged, and decreed by this Court, that the.....decree of the said District Court in this cause insofar as it adjudges Reissue No. 21,383 valid and infringed, be, and hereby is reversed and that the decree of the said District Court in all

other respects be, and hereby is affirmed, without costs in this court to either party.

[Endorsed]: Filed and entered Dec. 28, 1944. Paul P. O'Brien, Clerk.

United States Circuit Court of Appeals
for the Ninth Circuit

Excerpt from Proceedings of Monday, June 11, 1945

Before: Denman, Stephens and Healy,
Circuit Judges.

[Title of Cause.]

ORDER DIRECTING FILING OF OPINIONS ON PETITON FOR REHEARNG AND DENYING PETITION

By direction of the Court, Ordered that the per curiam opinion and concurring opinion of Denman, Circuit Judge, on petition for rehearing be forthwith filed by the clerk.

Upon consideration of the petition of Halliburton Oil Well Cementing Company, filed January 27, 1945, and within time allowed therefor by rule of court, and of the reply of Walker, et al., thereto, filed February 10, 1945, and by direction of the Court, It Is Ordered that said petition for rehearing be, and hereby is denied.

[Title of Circuit Court of Appeals and Cause.]

UPON PETITION FOR REHEARING

Before: Denman, Stephens, and Healy,
Circuit Judges Per Curiam

PER CURIAM OPINION AND CONCURRING

In its petition for rehearing appellant, Halliburton Oil Well Cementing Company, assumes that the court in ruling on Walker's patent No. 2,156,519 failed to consider the cases of General Electric Co. v. Wabash Appliance Corp., 314 U. S. 364, and Davis Sewing Mach. Co. v. New Departure Mfg. Co., 217 Fed. 775, particularly the first of these decisions. Halliburton is mistaken. In the General Electric case the claim considered was not one for a combination of elements, but a claim for a single element. Here, the claims are for a combination of elements. They sufficiently define the limits of the inventon to enable those havng knowledge of acoustics and of the principles of the physics of sound to determine what is covered and what is beyond the scope of the claimed invention.

Petition for rehearing is denied.

Denman, Circuit Judge, concurring in the denial of the petition for rehearing:

Appellant's principal contention on its petition for rehearing concerns the patenting of a combination of functional means such as claimed in typical claims 1 and 14, cited in the opinion.

Claim 1 is for a combination in "[A] an apparatus for determining the location of an obstruction in a well having therein a string of assembled tubing sections interconnected with each other by coupling collars"

of the following three "means," with

[B] "means communicating with said well for creating a pressure impulse in said well," and

[C] "echo receiving means including a pressure responsive device exposed to said well for receiving pressure impulses from the well and for measuring the lapse of time between the creation of the impulse and the arrival of said receiving means of the echo from said obstruction," and

[D] "means associated with said pressure responsive device for tuning said receiving means to the frequency of echoes from the tubing collars of said tubing sections to clearly distinguish the echoes from said couplings from each other."

Each of B, C and D describes a function but, appellant contends, fails to describe how the apparatus is to perform the function, as required by R.S. 4488, 35 U.S.C. § 33, cf. General Electric Co. v. Wabash, 304 U.S. 364, 368.

No case is cited in which such a combination of means alone has been sought and the case seems of novel import. It is apparent that a combination of three means is valid only if a combination of all the various means for accomplishing each of the three functions is to be deemed included in the claim. It would establish invalidity of the patent if prior thereto any one of the several means of

each of the all-inclusive means so had been combined.

Appellant has shown no such prior combination of any one of each of the three means. General Electric Co. v. Wabash, supra, is distinguishable. Unlike the instant patent for a combination, the patent there was for a specific product and its production was described in functional instead of a specific physica determinant. Since the combination of all such means has novelty and usefulness, I agree in the denial of the petition for rehearing.

[Endorsed]: Per curiam Opinion and Concurring Opinion upon petition for rehearing. Filed Jun. 12, 1945. Paul P. O'Brien, Clerk.

United States Circuit Court of Appeals
for the Ninth Circuit

CERTIFICATE OF CLERK, U. S. CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT, TO RECORD CERTIFIED UNDER RULE 38 OF THE REVISED RULES OF THE SUPREME COURT OF THE UNITED STATES.

I, Paul P. O'Brien, as Clerk of the United States Circuit Court of Appeals for the Ninth Circuit, do hereby certify the foregoing Transcript of Record in Six Volumes consisting of sixteen hundred sixteen (1616) pages, numbered from and including 1 to and including 1616 together with original exhibits transmitted herewith, to be a full, true and correct copy of the entire record of the above-entitled case in the said Circuit Court of Appeals, made pursuant to request of counsel for the Halliburton Oil Well Cementing Co., and certified under Rule 38 of the Revised Rules of the Supreme Court of the United States, as the originals thereof remain on file and appear of record in my office.

Attest my hand and the seal of the said the United States Circuit Court of Appeals for the Ninth Circuit, at the City of San Francisco, in the State of California, this 6th day of July, 1945.

[Seal] PAUL P. O'BRIEN,
Clerk

SUPREME COURT OF THE UNITED STATES

ORDER ALLOWING CERTIORARI—Filed October 15, 1945

The order of October 8, 1945, denying the petition for writ of certiorari in this case is vacated and the petition for writ of certiorari to the United States Circuit Court of Appeals for the Ninth Circuit is granted.

And it is further ordered that the duly certified copy of the transcript of the proceedings below which accompanied the petition shall be treated as though filed in response to such writ.

Mr. Justice Jackson took no part in the consideration or decision of this application.

FILE COPY

FILED
AUG 2 1945
CHARLES ELMORE CROPLEY
CLERK

IN THE

Supreme Court of The United States

October Term, 1945

No. 290 24

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Petitioner,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Respondents.

PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT.

EARL BABCOCK,

Attorney for Petitioner.

MCCORMICK AND HENDERSON, INC., CHICAGO

INDEX.

Petition for Writ of Certiorari.

PAGE

Summary Statement of the Matter Involved 2-4

Questions Presented 4

Question 1. Is the doctrine of the case of *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, 82 L. Ed. 1402, condemning the use of indefinite and functional language at the exact point of novelty in a claim of a patent, applicable to a claim on a combination of elements, or should the doctrine be limited, as held (R. 1614, 1616) by the Ninth Circuit Court of Appeals, to a claim on a "single element" or "specific product?" 4

Question 2. Is the doctrine of the case of *Schriber-Schroth* v. *Cleveland Trust Co.*, 311 U. S. 211, 85 L. Ed. 132, precluding the giving of a claim of a patent such scope as will include within its terms subject matter rejected and cancelled while the application for patent was pending, applicable to a situation where an inventor files two applications on different species of his invention, the rejection and cancelation taking place in one and the claim in suit issuing in the other? 4

Reasons Relied upon for the Allowance of the Writ of Certiorari 5

1. That the Circuit Court of Appeals for the Ninth Circuit, by Ruling That "Means . . . for Tuning . . ." in Claim 1 and Like Functional Statements in Claims 13, 14, 15 and 17 of Patent 2,156,519 Define the Only Novel Element in the Claims "With Sufficient Distinctness and Clarity to Comply with the Statute," (R. 1600) Has Rendered a Decision in Direct Conflict With the Decision of This Court in General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, 82 L. Ed. 1402 5

PAGE

2. That the Circuit Court of Appeals for the Ninth Circuit, by Ignoring the Rejection, Cancelation and Abandonment of a Claim in a Copending Application for Patent, Has so Construed the Claims in Suit as to Cause Them to Cover Subject Matter Refused Respondents by the Patent Office and Has Imposed Undue Restrictions on the Rules Governing the Construction of Claims Set Forth in Schriber-Schroth Co. v. Cleveland Trust Co., 311 U. S. 211, 220, 221, 85 L. Ed. 132, 137, 138 5

3. That Issues of Great Moment to the Public Are Involved; and Further Litigation of Patent 2,156,519 Which Might Result in Conflict Between Circuit Courts of Appeals Is Improbable Because Petitioner Is the Only Competitor of Respondents Offering the Services of Sonic Fluid Level Determining Apparatus to the Oil Industry 5

BRIEF IN SUPPORT OF PETITION.

The Opinions of the Courts Below 7

Jurisdiction 7

Statement 8

Statutes 8

Specification of Errors 9

Summary of Argument 10

Argument 10

Reason No. 1 10

Reason No. 2 13

Reason No. 3 15

Conclusion 16

PAGE

STATUTES.

Judicial Code, Sec. 240(a), (28 U.S.C., 347) 7
R. S. Sec. 4886, (U.S.C. title 35, sec. 31) 8
R. S. Sec. 4888, (U.S.C., title 35, sec. 33) 8, 12

CITATIONS.

Bestwall Mfg. Co. v. U. S. Gypsum Co., 270 F. 542, (C.C.A. 7) 14
Cole v. Ralph, 252 U. S. 286, 64 L. Ed. 567 14
48 C. J. 218 14
Davis Sewing Mach. Co. v. New Departure Mfg. Co., 217 F. 775, (C.C.A. 6) 11
Dodge Needle Co. v. Jones, 159 F. 715, (C.C.A. 3) 14
Electrical Accumulator Co. v. Brush Elec. Co., 52 F. 130, (C.C.A. 2) 14
Exhibit Supply Co. v. Ace Patents Corp., 315 U. S. 126, 86 L. Ed. 736 ..... 8, 13
General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, 82 L. Ed. 1402 ..... 3, 4, 5, 9, 10, 16
Gynex Corp. v. Dilex Institute of Feminine Hygiene, Inc., 85 F. (2d) 103, (C.C.A. 2) 11
Lewis Blind-Stitch Mach. Co. v. Arbetter Felling Mach. Co., 208 F. 992 (D. C., N. D., Ill.), affirmed 219 F. 557 14
Mackay Radio & Telegraph Co. v. Radio Corp. of America, 306 U. S. 86, 83 L. Ed. 506 ..... 7, 15
Muncie Gear Works v. Outboard M. & Mfg. Co., 315 U. S. 759, 86 L. Ed. 1171 ..... 8, 15
North Am. Chem. Co. v. Dexter, 252 F. 148, (D.C., E.D., Wisc.) 14
Precision Instr. Co. v. Automotive M. Mach. Co., ... U. S. ...., 89 L. Ed. ....., (Case No. 377, decided April 23, 1945) 15
Schriber-Schroth Co. v. Cleveland Trust Co., 311 U. S. 211, 85 L. Ed. 132 ..... 4, 5, 7, 9, 13, 16
Tampax, Inc. v. Personal Products Corp., 123 F. (2d) 722, (C.C.A. 2), cert. den. 316 U. S. 665, 86 L. Ed. 1741 14
United Carbon Co. v. Binney & Smith Co., 317 U. S. 228, 87 L. Ed. 232 ..... 7, 13, 15

IN THE

SUPREME COURT OF THE UNITED STATES

October Term, 1945

No. .....

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Petitioner,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Respondents.

PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT.

To the Honorable the Chief Justice and Associate Justices of the Supreme Court of the United States:

Your petitioner, Halliburton Oil Well Cementing Company respectfully prays that a writ of certiorari issue to the United States Circuit Court of Appeals for the Ninth Circuit to review the decree of that Court holding valid and infringed United States Letters Patent 2,156,519, which decree was entered on December 28, 1944 (R. 1612). Petition for rehearing was denied on June 11, 1945 (R. 1613).

A certified transcript of the record in the case, including the proceedings in the Circuit Court of Appeals is furnished herewith in compliance with Rule 38 of the Rules of this Court.

Summary Statement of the Matter Involved.

This suit was brought by Respondents against Petitioner for infringement of three United States patents issued to Cranford P. Walker. Two of the patents, Nos. 2,209,944 and Reissue 21,383 were held invalid by the Circuit Court of Appeals. This petition seeks a review of the portion of the decree affirming the District Court and holding valid and infringed certain claims of the third patent, No. 2,156,519 granted May 2, 1939 for "Means for Measuring the Location of Obstructions in Wells." (A copy of this patent appears in Vol. III, Book of Exhibits, R. 587).

As to validity, the language of the claims raises a question of law. Patent 2,156,519 is concerned with the location of the level of fluid in a well, such as an oil well. The apparatus disclosed includes a cylinder of gas under pressure and a valve for creating a pressure wave in a well and a system for recording on a chart the time when the wave is initiated and the time when echoes return from obstructions in the well. Apparatus of this type is old in the prior art, as in the patent to Lehr et al. (R. 1101). The novelty of the patent in suit was found by the District Court to reside in the addition of an adjustable pipe which functions as an acoustical tuned resonator so that better records can be made of echoes from collars on tubing in the well. (Findings of Fact Nos. 4, 5, 6, R. 28, 29). The Circuit Court of Appeals also held (R. 1599, 1600) that the novelty in the patent resided in this element, which it referred to as a "device which would enable the operator to tune up certain desirable echoes while tuning out undesirable ones," (R. 1600). This element is described in Claim 1 (R. 596) as "means ... for tuning ... " Similar phrases are used in claims 13, 14, 15 and 17 in suit (R. 597, 598). Judge Denman held such phrases to be functional (R. 1615), but the Court held (R.

1600) that these claims complied with the statute. The decision of this Court in the case of *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, 82 L. Ed. 1402, condemning the use of functional language to define novelty in claims, was distinguished on the ground that there the claim was for a single element, whereas here combination claims are involved. (See *per curiam* decision of the Court of Appeals denying petition for rehearing, R. 1614).

As to infringement, certain proceedings in the Patent Office raise a question of law. The recording system disclosed in patent 2,156,519 is mechanical. There is no showing or disclosure in this patent of an electrical recording system of any kind, or of electrical tuning means. In a copending application for patent, Serial No. 164,534 (Exhibit L, R. 953), filed by Respondent Walker, a system similar to that of patent 2,156,519 is disclosed, except that an electrical recording system is used to record the echoes, and electrical tuning means is provided to cause the recording system to respond particularly to echoes from tubing collars. In this copending application, claim 15 (R. 982) on the tuned electrical system was rejected (R. 1002) as involving no invention over prior art and cancelled (R. 1003). The rejected claim 15 reads squarely upon the accused device manufactured and used by Petitioner.

Petitioner's device is similar to the system of the patent in suit except that it uses a gun instead of a pressure cylinder and an electrical recording system instead of a mechanical one. To the amplifier an electrical filter is connected which, it has been held, tunes the circuit. When the filter is used, the accused device has been held to infringe patent 2,156,519.

The Circuit Court of Appeals ignored the proceedings in the Patent Office, accorded great breadth to the claims in suit and enjoined Petitioner from using an electrical system which the Patent Office specifically held (R. 1002) involved no invention over the prior art.

Petitioner is practically the only competitor of Respondents in the business of furnishing owners or operators of oil wells with sonic depth measuring apparatus (R. 204, 205, 216). The Gulf Oil Company has made and used such a device on some of its own wells, but has not offered to perform any service for others. Petitioner and Respondents are the only concerns offering this service to the oil industry. For this reason, conflict between Circuit Courts of Appeals on the question of validity of patent 2,156,519 is improbable.

Questions Presented.

The decree of the Ninth Circuit Court of Appeals raises two questions of law:

Question 1. Is the doctrine of the case of *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, 82 L. Ed. 1402, condemning the use of indefinite and functional language at the exact point of novelty in a claim of a patent, applicable to a claim on a combination of elements, or should the doctrine be limited, as held (R. 1614, 1616) by the Ninth Circuit Court of Appeals, to a claim on a "single element" or "specific product?"

Question 2. Is the doctrine of the case of *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, 85 L. Ed. 132, precluding the giving of a claim of a patent such scope as will include within its terms subject matter rejected and cancelled while the application for patent was pending, applicable to a situation where an inventor files two applications on different species of his invention, the rejection and cancelation taking place in one and the claim in suit issuing in the other?

Reasons Relied Upon for the Allowance of the Writ of Certiorari.

The discretionary power of the Court is invoked upon the following grounds:

1. That the Circuit Court of Appeals for the Ninth Circuit, by Ruling That "Means . . . for Tuning . . . " in Claim 1 and Like Functional Statements in Claims 13, 14, 15 and 17 of Patent 2,156,519 Define the Only Novel Element in the Claims "With Sufficient Distinctness and Clarity to Comply With the Statute," (R. 1600) Has Rendered a Decision in Direct Conflict With the Decision of This Court in General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, 82 L. Ed. 1402.

2. That the Circuit Court of Appeals for the Ninth Circuit, by Ignoring the Rejection, Cancelation and Abandonment of a Claim in a Copending Application for Patent, Has so Construed the Claims in Suit as to Cause Them to Cover Subject Matter Refused Respondents by the Patent Office and Has Imposed Undue Restrictions on the Rules Governing the Construction of Claims Set Forth in Schriber-Schroth Co. v. Cleveland Trust Co., 311 U. S. 211, 220, 221, 85 L. Ed. 132, 137, 138.

3. That Issues of Great Moment to the Public Are Involved; and Further Litigation of Patent 2,156,519 Which Might Result in Conflict Between Circuit Courts of Appeals Is Improbable Because Petitioner Is the Only Competitor of Respondents Offering the Services of Sonic Fluid Level Determining Apparatus to the Oil Industry.

For these reasons, it is respectfully submitted that this petition should be granted.

EARL BABCOCK,
Attorney for Petitioner.

STATE OF OKLAHOMA
COUNTY OF STEPHENS } ss.

EARL BABCOCK, being duly sworn, deposes and says:

That he is the attorney for the Petitioner herein, that he prepared the foregoing petition and that the allegations thereof are true, as he verily believes.

EARL BABCOCK,

Subscribed and sworn to before me this 30th day of July, 1945.

(Seal)

FAYE DALTON,
Notary Public.

My commission expires
August 14, 1947.

RIEF FOR PETITIONER IN SUPPORT OF PETITION FOR WRIT OF CERTIORARI.

The Opinions of the Courts Below.

The opinion of the Circuit Court of Appeals for the inth Circuit is reported at 146 F (2d) 817, and is in the cord filed herewith (R. 1594). The opinion *per curiam*, d the concurring opinion of Judge Denman, denying the tition for rehearing appear in the record (R. 1614). The dings of fact and conclusions of law of the District Court pear in the record (R. 28-32.)

Jurisdiction.

The grounds for jurisdiction are:

1. The decree was entered December 28, 1944 (R. 1613). tition for rehearing on patent 2,156,519, upon which view is sought, was denied June 11, 1945 (R. 1613).

2. The decree was rendered in a suit in equity brought der the Patent Statutes to determine the issues of validity d infringement of letters patent issued by virtue of vised Statute No. 4886 (U. S. C., title 35, sec. 31).

3. The statute under which the jurisdiction of this urt is invoked is Sec. 240 (a) of the Judicial Code, 28 S. C. 347, as amended by the Act of February 13, 1925.

4. Cases believed to sustain the jurisdiction are:

United Carbon Co. v. *Binney & Smith Co.*, 317 U. S. 228, 87 L. Ed. 232;

Schriber-Schroth Co. v. *Cleveland Trust Co.*, 311 U. S. 211, 217, 85 L. Ed. 132, 135;

Mackay Radio & Telegraph Co. v. *Radio Corp. of America*, 306 U. S. 86, 89, 83 L. Ed. 506, 508;

Exhibit Supply Co. v. *Ace Patents Corp.*, 315 U. S. 126, 128, 86 L. Ed. 736, 740;

Muncie Gear Works v. *Outboard M. & Mfg. Co.*, 315 U. S. 759, 766, 86 L. Ed. 1171, 1177.

Statement.

The facts are sufficiently stated in the petition.

Statutes.

The statutes under which this case arises which are necessary to be considered are as follows:

R.S. Sec. 4886 (U. S. C., title 35, sec. 31). "Any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvements thereof, ... not known or used by others in this country, before his invention or discovery thereof, and not patented or described in any printed publication in this or any foreign country, before his invention or discovery thereof or more than one year prior to his application, and not in public use or on sale in this country for more than one year prior to his application, unless the same is proved to have been abandoned, may, upon payment of the fees required by law, and other due proceeding had, obtain a patent therefor."

R.S. Sec. 4888 (U. S. C., title 35, sec. 33). "Before any inventor or discoverer shall receive a patent for his invention or discovery, he shall make application therefor, in writing, to the Commissioner of Patents, and shall file in the Patent Office a written description of the same, and of the manner and process of making, constructing, compounding, and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct, compound, and use the same; and in case of a machine, he shall explain the principle thereof, and the

best mode in which he has contemplated applying that principle, so as to distinguish it from other inventions; and he shall particularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery.... "

Specifications of Errors.

he errors which Petitioner will urge if the writ of cer-ari is allowed, are that the Circuit Court of Appeals for Ninth Circuit erred:

In affirming the decree of the District Court in hold-Walker patent 2,156,519 to be valid and infringed by tioner;

In failing to reverse the decree of the District Court olding the Walker patent 2,156,519 valid and infringed 'etitioner;

In holding Walker patent 2,156,519 to be valid;

In holding Walker patent 2,156,519 to have been in-ged by Petitioner;

In failing to hold that the law established by the deci-of this Court in *General Electric* v. *Wabash Appliance p.*, 304 U. S. 364, 82 L. Ed. 1402, was controlling and ositive of the litigation;

In failing to hold that the law established by the sion of this Court in *Schriber-Schroth Co.* v. *Cleveland st Co.*, 311 U. S. 211, 85 L. Ed. 132, was controlling and ositive of the litigation;

In holding that claims 1, 13, 14, 15 and 17 of Walker nt 2,156,519 define the alleged improvement thereof sufficient distinctness and clarity to comply with R. Sec. 4888 requiring a patentee to "particularly point and distinctly claim the part, improvement, or combina-which he claims as his invention or discovery;"

8. In holding that claims 1, 13, 14, 15 and 17 of Walker patent 2,156,519 cover the use of electrical apparatus not shown or described in the patent, after the Patent Office had refused to grant Walker a claim specific to such electrical apparatus in a copending application for patent.

Summary of Argument.

The points of the argument follow the reasons relied upon for the allowance of the writ of certiorari (p. 5, supra).

ARGUMENT.

1. That the Circuit Court of Appeals for the Ninth Circuit, by Ruling That "Means . . . for Tuning . . . " in Claim 1 and Like Functional Statements in Claims 13, 14, 15 and 17 of Patent 2,156,519 Define the Only Novel Element in the Claims "With Sufficient Distinctness and Clarity to Comply With the Statute," (R. 1600) Has Rendered a Decision in Direct Conflict With the Decision of This Court in General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, 82 L. Ed. 1402.

In the *General Electric* v. *Wabash* case, the patent involved had previously been held valid by the Circuit Court of Appeals for the Ninth Circuit. This Court, speaking through Mr. Justice Reed, said:

> "The claim uses indeterminate adjectives which describe the function of the grains to the exclusion of any structural definition, and thus falls within the condemnation of the doctrine that a patentee may not broaden his product claims by describing the product in terms of function. (Holland Furniture Co. v. Perkins Glue Co. 277 U. S. 245, 256-258, 72 L. Ed. 868, 872, 873, 48 S. Ct. 474, and cases cited). Claim 25 vividly illustrates the vice of a description in terms of function. 'As a description of the invention it is insufficient and if al-

lowed would extend the monopoly beyond the invention.' (277 U. S. at 258). The Court of Appeals for the Ninth Circuit relied on the fact that the description in the claims is not 'wholly' functional. 80 F. (2d) 958, 963. But the vice of a functional claim exists not only when a claim is 'wholly' functional, if that is ever true, but also when the inventor is painstaking when he recites what has already been seen, and then uses conveniently functional language at the exact point of novelty. (See Gynex Corp. v. Dilex Institute (C. C. A. 2d) 85 F. (2d) 103, 105; Davis Sewing Mach. Co. v. New Departure Co. (C. C. A. 6th) 217 F. 775, at 782)." 304 U. S. 364, 371, 82 L. Ed. 1402, 1406-1407.

n its decision denying the petition for rehearing in the e at bar (R. 1614) the Circuit Court of Appeals for the ith Circuit points out that in the *General Electric* v. *bash* case the claim considered was for a single element ereas the claims here are for a combination of elements. lge Denman states (R. 1615) that for this reason "the e seems of novel import." We submit that the interated limitation in the doctrine is not warranted.

n the *General Electric* case, in support of its condemna- of the use of conveniently functional language at the ct point of novelty, this Court cited two Circuit Court Appeals cases where claims to combinations of elements e under consideration. In *Gynex Corp.* v. *Dilex Institute Feminine Hygiene, Inc.*, 85 F. (2d) 103, C. C. A. 2, claim of the Beatty patent 1,870,942 covered a combination F. (2d) 105.) In *Davis Sewing Machine Co.* v. *New Deture Mfg. Co.*, 217 F. 775, C. C. A. 6, Judge Denison made extensive analysis of the law on the use of the words eans" and "mechanism" in combination claims. He ed:

"Reliance is also placed upon the opinion of this court, speaking by Judge (afterwards Mr. Justice) Lurton, in Tyden v. Ohio Table Co., 152 Fed. 183, 81

C. C. A. 425. In this case, the claim calling for 'means' was held invalid because it covered all means for accomplishing the result, and so was functional. We do not question the application of the rule as made to the facts of that case; but we do not understand that a claim is functional and invalid merely because one of its specified elements is 'means,' as in the Tyden Case, or 'mechanism', as in the present case. This result may or may not follow, depending upon whether the all-inclusive term is used with reference to the element or subcombination which is *the real point and gist of the invention,* or *whether it is used with reference to elements or parts of the combination already well known* and designed only to co-operate with the new element in order to make a completely operative unit. In other words, *where used with reference to the exact point of novelty,* 'means' or 'mechanism' *may expose the claim to attack* on the ground that it is functional; in that respect, each case will present a problem by itself. But where used with reference to the make-up of the field in which the real invention finds its usefulness or with reference to the connecting parts which permit the salient novelty of the invention to accomplish its function, these words are only a convenient formula of the broadest equivalency of which the real invention permits." (217 F. 775, 782-783) (Emphasis added).

In his opinion (R. 1614, 1615) on the denial of the petition for rehearing in the case at bar, Judge Denman lists three means (designating them B, C and D) of claim 1 of Walker patent 2,156,519. There can be no objection to the use of functional language in clauses B and C. These are directed to elements of the prior art, and under the doctrine of the *Davis Sewing Machine* case, it is proper to define those elements merely as "means". But clause D is directed to the real point and gist of the invention, and defines it only by the word "means" and its function. To hold that this is in compliance with R. S. Sec. 4888 is, we submit, in

irect conflict with the decision of this Court in the *General Electric* v. *Wabash* case. See also *United Carbon Co.* v. *Binney & Smith Co.*, 317 U. S. 228, 87 L. Ed. 232.

2. That the Circuit Court of Appeals for the Ninth Circuit, by Ignoring the Rejection, Cancelation and Abandonment of a Claim in a Copending Application for Patent, Has So Construed the Claims in Suit as to Cause Them to Cover Subject Matter Refused Respondents by the Patent Office, and Has Imposed Undue Restrictions on the Rules Governing the Construction of Claims Set Forth in Schriber-Schroth Co. v. Cleveland Trust Co., 311 U. S. 211, 220, 221, 85 L. Ed. 132, 137, 138.

The claims of a patent must be so construed as not to cover subject matter rejected by the Patent Office. Cancelled claims are regarded as disclaimers and create an estoppel which bars the patentee from asserting a monopoly on the subject matter dedicated to the public by the cancelled claims. *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, 220, 221, 85 L. Ed. 132, 137, 138; see also *Exhibit Supply Co.* v. *Ace Patents Corp.*, 315 U. S. 126, 86 L. Ed. 736. In many other cases, this Court has applied the doctrine of file wrapper estoppel, but we have been able to find no case in which the facts are exactly the same as those in the case at bar.

Walker could have filed one application for patent covering the two systems he had conceived. Instead, he filed two applications, one on the mechanical system and one on the electrical. Had both ideas been presented in one application and those on the electrical system been rejected on the prior art and cancelled, the facts would be the same as in the above cited cases. No reason is apparent why the rules laid down by this Court as to the interpretation of claims do not apply to acts in copending applications.

"Where different applications by a patentee and interference proceedings relating to the same subject matter are pending at the same time, all may be considered in determining the construction of the patent as granted. . . .

"Where an inventor divides up his invention so as to present certain elements in different patents, he is thereby limited to a more strict and narrow construction than might have been otherwise necessary." 48 C. J. 218.

See also:

Tampax, Inc. v. *Personal Products Corp.*, 123 F. (2d) 722, 723 (C. C. A. 2), cert. den. 316 U. S. 665, 86 L. Ed. 1741;

Dodge Needle Co. v. *Jones*, 159 F. 715, 722 (C. C. A. 3);

Bestwall Mfg. Co. v. *U. S. Gypsum Co.*, 270 F. 542, 545, (C. C. A. 7);

North Am. Chem. Co. v. *Dexter*, 252 F. 148, 160, 161 (D. C., E. D. Wisc.);

Lewis Blind-Stitch Mach. Co. v. *Arbetter Felling Mach. Co.*, 208 F. 992, 1001 (D. C., N. D. Ill.), affirmed 219 F. 557, 560;

Electrical Accumulator Co. v. *Brush Elec. Co.*, 52 F. 130, 142 (C. C. A. 2).

While this defense was pleaded (Art. XVI of the Answer, R. 17), assigned as error (No. 6, R. 40) and presented to the Circuit Court of Appeals both in the main brief and in the petition for rehearing, no mention whatever is made of it by the Circuit Court of Appeals either in its Opinion or in its Denial of the petition for rehearing. We ask that this important question of law be decided by this Court, or the case remanded to the Circuit Court of Appeals for action thereon. *Cole* v. *Ralph*, 252 U. S. 286, 290, 64 L. Ed. 567, 574.

3. That Issues of Great Moment to the Public Are Involved; and Further Litigation of Patent 2,156,519 Which Might Result in Conflict Between Circuit Courts of Appeals Is Improbable Because Petitioner Is the Only Competitor of Respondents Offering the Services of Sonic Fluid Level Determining Apparatus to the Oil Industry.

Patent 2,156,519 having been held valid and infringed, rights of the public are involved in this litigation.

> "The possession and assertion of patent rights are 'issues of great moment to the public'." *Precision Instr. Mfg. Co.* v. *Automotive M. Mach. Co.*, ... U. S. ...., 89 L. Ed. ..... (Case No. 377, decided April 23, 1945).
>
> "To sustain claims so indefinite as not to give the notice required by the statute would be in direct contravention of the public interest which Congress therein (R. S. Sec. 4888, 35 U. S. C. A. sec. 33) recognized and sought to protect." *United Carbon Co.* v. *Binney & Smith Co.*, 317 U. S. 228, 233, 87 L. Ed. 232, 235.
>
> "To sustain the claims in question upon the established and admitted facts would require a plain disregard of the public interest sought to be safeguarded by the patent statutes, and so frequently present but so seldom adequately represented in patent litigation." *Muncie Gear Works* v. *Outboard M. & Mfg. Co.*, 315 U. S. 759, 768, 86 L. Ed. 1171, 1178.

Where the validity and infringement of a patent are in doubt and where it is improbable that conflict between Circuit Courts of Appeals will occur, due to the fact that only the litigants are engaged in competition thereon, certiorari may be granted. *Mackay Radio & Telegraph Co.* v. *Radio Corp. of America*, 306 U. S. 86, 89, 83 L. Ed. 506, 508.

Conclusion.

The decisions of this Court in the cases of *Ge*
Electric Co. v. *Wabash Appliance Co.*, 304 U. S. 36
Schriber-Schroth Co. v. *Cleveland Trust Co.*, 311 U. S
are concerned with doctrines of long standing on the
struction of claims in a patent. If these doctrines d
apply to certain types of claims or to certain proceed
in the Patent Office, the limitations thereon should b
plied uniformly. On the other hand, if the doctrine o
General Electric case applies to combination claims a
as to claims on a specific element, and if that of the *Sch*
Schroth case applies to all relevant proceedings i
Patent Office as well as to those in the application
contains the claim to be construed, rights of the publ
well as rights of Petitioner have been seriously imp
by the decision of the Circuit Court of Appeals fo
Ninth Circuit.

Therefore, your Petitioner respectfully submits tha
questions of law involved are of great importance
should be determined by this Court.

Respectfully submitted,

EARL BABCOCK,
Attorney for Petitione

NOV 19 1945
CHARLES ELMORE CROPLEY

No. [redacted] 24

In the

Supreme Court of the United States

(OCTOBER TERM, 1945)

HALLIBURTON OIL WELL CEMENTING COMPANY,
a Delaware corporation,
Petitioner,

VERSUS

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM doing business as Depthograph Company, a copartnership,
Respondents.

BRIEF FOR HALLIBURTON OIL WELL CEMENTING COMPANY, PETITIONER

EARL BABCOCK,
Duncan, Oklahoma,
Attorney for Petitioner.

November, 1945

TIERBACK TYPESETTING CO. 13 S. Walker, Oklahoma City 4, Okla.

TOPICAL INDEX

	PAGE
Statement of the Case	1
Opinions Below	2
Jurisdiction	2
Specification of Errors	3
Questions Presented	4
History of the Development of the Art	5
Patent in Suit is for an "improvement"	5
In 1898, Batcheller patent disclosed use of echoes to locate obstructions	6
In 1927, Union Oil Co. used gun and electrical recorder to locate obstructions in oil wells	6
In 1933, Lehr and Wyatt of the Shell Oil Co. used a device creating a pressure impulse for locating obstructions in wells	6
The disclosure of the Lehr and Wyatt patent	9
The Novelty in the Patent in Suit	10
The addition of an acoustical tuned resonator to the Lehr and Wyatt system	13
An acoustical tuned resonator was old in an analogous art	14
The Accused Device	17
The "Echo-Meter" uses a gun instead of a pressure impulse chamber and an electrical recorder particularly designed to respond to gun shots	18
The hot-wire microphone used was invented by Major Tucker to record gun shots in 1918	18

INDEX—(Continued)

PAGE

Details of the Echo-Meter 23

The records made with an Echo-Meter are not the same as those made with the apparatus of the patent in suit 24

The Echo-Meter has an electrical filter in the amplifier circuit 27

The holding of infringement is based upon the use of a filter 28

Filters and tuning devices were well known in the art 28

Walker, in his early experiments, purchased "on the market" an amplifier with a built-in filter 29

Analysis of the Claims in Suit 33

The only novel element in the claims—the acoustical tuned resonator—is defined only as "means" for accomplishing the desired function 34

An electrical filter is not a tuning device and has nothing in common with a tuned pipe 36

Extrinsic evidence as to equivalency between a tuned pipe and an electrical filter should not be considered 36

The patent in suit itself precludes broad interpretation 37

Proceedings in the Patent Office 38

Two applications filed contemporaneously by Walker, one on a mechanical recorder with an acoustical resonator, and the other on an electrical recorder with an electrical filter 39

INDEX—(Continued)

PAGE

In the electrical application, the Examiner rejected a claim to the use of an electrical filter as involving no invention over the prior Lehr and Wyatt patent and Walker cancelled the claim 40

In the mechanical application, which matured into the patent in suit, several material limitations were introduced to avoid rejections on the prior art 41

The proceedings show that it was not the intention of the Patent Office to grant claims in the mechanical application covering a device using a gun and an electrical recorder..... 42

Summary of Argument..... 46

The Claims in Suit are Invalid..... 46

The Claims in Suit are not Infringed..... 46

Conclusion 46

Argument 47

The Claims in Suit are Invalid..... 47

The statutes require a patentee to describe his invention accurately and claim it particularly 47

The Claims in Suit are to an old combination... 50

The word "means" followed by a recital of function is too indefinite to comply with the statute where it is used to define the only novel element in a claim 50

In General Electric Co. v. Wabash Appliance Corp., 304 U. S 364, the use of indefinite and functional language at the exact point of novelty in a claim was condemned..... 53

INDEX—(Continued)

PAGE

The Claims in Suit are not Infringed 58

For an accused device to be the equivalent of that of a patent, there must be (1) substantially the same means, (2) substantially the same operation, and (3) substantially the same result 58

In the present case not one of these requirements is met 58

Tests of Equivalency 61

In Schriber-Schroth Co. v. Cleveland Trust Co., 311 U. S. 211, it was held that the doctrine of equivalents cannot be used to expand allowed claims to cover subject matter of cancelled claims 66

The rejection and cancellation of claim 15 in Walker's co-pending application, Exhibit L, prevents him from resorting to the doctrine of equivalents in the patent in suit to cover what he there abandoned 68

The rule is that where different applications relating to the same subject matter are pending, all may be considered in construing allowed claims 69

The file wrapper of the patent in suit precludes such broad interpretation as is necessary to cover Petitioner's Echo-Meter 74

Conclusion 75

PAGE

AUTHORITIES

CASES:

Altoona Pub. Theatres v. Am. Tri-Ergon Corp., 294 U. S. 477, 79 L. Ed. 1005 ..... 17, 36
American Steel & Wire Co. v. Denning Wire & F. Co., 176 Fed. 564, affirmed 194 Fed. 117 (C. C. A. 8) 58

Bates v. Coe, 98 U. S. 31, 25 L. Ed. 68 58
Buono v. Yankee Maid Dress Corp., 77 Fed. (2d) 274 (C. C. A. 2) 52
Burr v. Duryee, 68 U. S. 531, 17 L. Ed. 650 ..... 18, 57

Cimiotti Unhairing Co. v. American Fur Ref. Co., 198 U. S. 399, 49 L. Ed. 1100 59
Corbin Cabinet Lock Co. v. Eagle Lock Co., 150 U. S. 38, 37 L. Ed. 989 67
Corning v. Burden, 56 U. S. 252, 14 L. Ed. 683 ..... 38, 49

Davis Sewing Machine Co. v. New Departure Mfg. Co., 217 Fed. 775 (C. C. A. 6) 51, 52, 53
Dodge Needle Co. v. Jones, 159 Fed. 715 (C. C. A. 3) 72
Dwight & Lloyd Sintering Co. v. Greenawalt, 27 Fed. (2d) 823, 832 (C. C. A. 2) 36

Electric R. R. Signal Co. v. Hall Railway Signal Co., 114 U. S. 87, 29 L. Ed. 96 ..... 38, 45
Exhibit Supply Co. v. Ace Patents Corp., 315 U. S. 126, 86 L. Ed. 736 ..... 3, 66

Ferguson, In re, 83 Fed. (2d) 693 (C. C. P. A.) 52
Field v. DeComeau, 116 U. S. 187, 29 L. Ed. 596 59
Firestone Tire and Rubber Co. v. United States Rubber Co., 79 Fed. (2d) 948 (C. C. A. 6) (Cert. denied 298 U. S. 679) 38, 53
Fuller v. Yentzer, 94 U. S. 288, 24 L. Ed. 103 38

General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, 82 L. Ed. 1402 ..... 3, 4, 46, 49, 53, 55, 56, 75

INDEX—(Continued)

PAGE

General Tire and Rubber Co. v. Fisk Rubber Corp., 104 Fed. (2d) 740 (C. C. A. 6) 52

Goodyear Dental Vulcanite Co. v. Davis, 102 U. S. 222, 26 L. Ed. 149 ..... 38, 45

Heidbrink v. Hardessen Co., 25 Fed. (2d) 8 (C. C. A. 7) 52

Hollingshead Co. v. Bassick Mfg. Co., 73 Fed. (2d) 543 (C. C. A. 6) 53

Hubbell v. United States, 179 U. S. 77, 45 L. Ed. 95.. 67

I. T. S. Rubber Co. v. Essex Rubber Co., 272 U. S. 429, 71 L. Ed. 335 66

Lewis Blind-Stitch Mach. Co. v. Arbetter Felling Machine Co., 208 Fed. 992 (D.C. N.D. Illinois E.D.) 72

Lincoln Engineering Co. v. Stewart-Warner Corp., 303 U. S. 545, 82 L. Ed. 1008..... 50

Mackay Radio & Telegraph Co. v. Radio Corp. of America, 306 U. S. 86, 83 L. Ed. 506..... 3

Marconi Wireless Telegraph Co. v. United States, 320 U. S. 1, 87 L. Ed. 1731..... 28

Merrill v. Yoemans, 94 U. S. 568, 24 L. Ed. 235.... 47

Miller v. Eagle Mfg. Co., 151 U. S. 186, 38 L. Ed. 121.. 58

Morgan Envelope Co. v. Albany Perforated Wrapper Paper Co., 152 U. S. 425, 38 L. Ed. 500..... 67

Muncie Gear Works v. Outboard M. & Mfg. Co., 315 U. S. 759, 86 L. Ed. 1171..... 3

North American Chemical Co. v. Dexter, 252 Fed. 148 (D.C. E.D. Wisc.)..... 70

O. H. Jewell Filter Co. v. Jackson, 140 Fed. 340 (C. C. A. 8) 38

Permutit Co. v. Graver Corp., 284 U. S. 52, 76 L. Ed. 163 47

Roemer v. Peddie, 132 U. S. 313, 33 L. Ed. 382..... 67

INDEX—(Continued)

PAGE

Sargent v. Hall Safe & Lock Co., 114 U. S. 63, 29 L. Ed. 67 67
Schriber-Schroth Co. v. Cleveland Trust Co., 311 U. S. 211, 85 L. Ed. 132 ..... 3, 4, 46, 66, 68, 75
Shepard v. Carrigan, 116 U. S. 593, 29 L. Ed. 723 67
Sinclair and Carroll Co., Inc. v. Interchemical Corp., — U. S. —, No. 656, October Term, 1944 38
Spitzglass, In re, 96 Fed. (2d) 1002 (C. C. P. A.) 52

Tampax, Inc. v. Personal Products Corporation, 123 Fed. (2d) 722 (C. C. A. 2) 71
Tucker, In re, 46 Fed. (2d) 214 (C. C. P. A.) 52
Tyden v. Ohio Table Co., 152 Fed. 183 (C. C. A. 6) ..50, 51

Union Water-Meter Co. v. Desper, 101 U. S. 332, 25 L. Ed. 1024 58
United Carbon Co. v. Binney & Smith Co., 317 U. S. 228, 87 L. Ed. 232 ..... 3, 48
Universal Oil Products Co. v. Globe Oil & Ref. Co., 322 U. S. 471, 88 L. Ed. 1399 59

Weber Electric Co. v. Freeman Electric Co., 256 U. S. 668, 65 L. Ed. 1162 33
Westinghouse v. Boyden Power Brake Co., 170 U. S. 537, 42 L. Ed. 1136 ..... 58, 61
White v. Dunbar, 119 U. S. 47, 30 L. Ed. 303 33
White Tool and Supply Co. v. Air Reduction Co., 48 Fed. (2d) 720 (C. C. A. 6) 52

Yale Lock Mfg. Co. v. Sargent, 117 U. S. 373, 29 L. Ed. 950 59

STATUTES:

Revised Statutes, Sec. 4886 (U. S. C. title 35, sec. 31) .. 2, 49
Revised Statutes, Sec. 4888 (U. S. C. title 35, sec. 33) 47, 49, 56

INDEX—(Continued)

PAGE

TEXTBOOKS:

Corpus Juris, Vol. 48, p. 218 69

Walker on Patents (Deller's Ed.)
Vol. 2, p. 790 53
Vol. 3, p. 1707 61
Vol. 3, p. 1745 61
Vol. 3, pp. 1746-1750 62
Vol. 3, p. 1751 60

MISCELLANEOUS:

Webster's New International Dictionary
(2d Ed. 1938) 35

In the

Supreme Court of the United States

(OCTOBER TERM, 1945)

No. 290

HALLIBURTON OIL WELL CEMENTING COMPANY,
a Delaware corporation,
Petitioner,

VERSUS

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM
doing business as Depthograph Company
a copartnership,
Respondents.

BRIEF FOR HALLIBURTON OIL WELL CEMENTING COMPANY, PETITIONER

STATEMENT OF THE CASE

This is a suit for patent infringement. Cranford P. Walker, *et al.*, Respondents, sued Halliburton Oil Well Cementing Company, Petitioner, in the United States District Court for the Southern District of California, Central Division, on three patents issued to Cranford P. Walker. Two of these patents were held invalid by the Circuit Court of Appeals for the Ninth Circuit. The third patent in suit, No. 2,156,519 (R. 587) was held valid and infringed. Certiorari has been granted only as to patent 2,156,519.

Opinions Below

The District Court rendered no formal opinion, but the findings of fact and conclusions of law appear in the record (R. 28-32). The opinion of the Circuit Court of Appeals is reported at 146 Fed. (2d) 817 and is in the record (Vol. VI, R. 1594). The opinion *per curiam*, and the concurring opinion of Judge Denman, denying a petition for rehearing on patent 2,156,519 are reported at 149 Fed. (2d) 896 and appear in the record (R. 1614).

Jurisdiction

The petition for certiorari was granted October 15, 1945.

The grounds for jurisdiction are:

1. The decree holding patent 2,156,519 valid and infringed was entered December 28, 1944 (R. 1613). Petition for rehearing was denied June 11, 1945 (R. 1613).

2. The decree was rendered in a suit in equity brought under the Patent Statutes to determine the issues of validity and infringement of letters patent issued by virtue of Revised Statute No. 4886 (U. S. C., Title 35, Sec. 31).

3. The statute under which the jurisdiction of this Court is invoked is Sec. 240 (a) of the Judicial Code, 28 U. S. C. 347, as amended by the Act of February 13, 1925.

4. Cases which sustain the jurisdiction are:

—*United Carbon Co.* v. *Binney & Smith Co.*, 317 U. S. 228, 87 L. Ed. 232;

Schriber-Schroth Co. v. *Cleveland Trust Co.*, 311 U. S. 211, 217, 85 L. Ed. 132, 135;

Mackay Radio & Telegraph Co. v. *Radio Corp. of America*, 306 U. S. 86, 89, 83 L. Ed. 506, 508;

Exhibit Supply Co. v. *Ace Patents Corp.*, 315 U. S. 126, 128, 86 L. Ed. 736, 740;

Muncie Gear Works v. *Outboard M. & Mfg. Co.*, 315 U. S. 759, 766, 86 L. Ed. 1171, 1177.

Specification of Errors

The errors urged by Petitioner are that the Circuit Court of Appeals for the Ninth Circuit erred:

1. In affirming the decree of the District Court in holding Walker patent 2,156,519 to be valid and infringed by Petitioner;

2. In failing to reverse the decree of the District Court in holding the Walker patent 2,156,519 valid and infringed by Petitioner;

3. In holding Walker patent 2,156,519 to be valid;

4. In holding Walker patent 2,156,519 to have been infringed by Petitioner;

5. In failing to hold that the law established by the decision of this Court in *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, 82 L. Ed. 1402, was controlling and dispositive of the litigation;

6. In failing to hold that the law established by the decision of this Court in *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, 85 L. Ed. 132, was controlling and dispositive of the litigation;

7. In holding that claims 1, 13, 14, 15 and 17 of Walker patent 2,156,519 define the alleged improvement thereof with sufficient distinctness and clarity to comply with R. S. Sec. 4888 requiring a patentee to "particularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery;"

8. In holding that claims 1, 13, 14, 15 and 17 of Walker patent 2,156,519 cover the use of electrical apparatus not shown or described in the patent, after the Patent Office had refused to grant Walker a claim specific to such electrical apparatus in a copending application for patent.

Questions Presented

The questions presented by the petition are:

Question 1. Is the doctrine of the case of *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, 82 L. Ed. 1402, condemning the use of indefinite and functional language at the exact point of novelty in a claim of a patent, applicable to a claim on a combination of elements, or should the doctrine be limited, as held (R. 1614, 1616) by the Ninth Circuit Court of Appeals, to a claim on a "single element" or "specific product?"

Question 2. Is the doctrine of the case of *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, 85 L.

Ed. 132, precluding the giving of a claim of a patent such scope as will include within its terms subject matter rejected and cancelled while the application for patent was pending, applicable to a situation where an inventor files two applications on different species of his invention, the rejection and cancellation taking place in one and the claim in suit issuing in the other?

History of the Development of the Art

Patent 2,156,519 (R. 587) is concerned with the location of the level of fluid or an obstruction in a well, such as an oil well. The apparatus disclosed includes a cylinder of gas under pressure adapted to be connected to the casing of the well. A quick opening valve is provided so that the gas may enter the well rapidly and create a pressure wave in the annular space between the casing and tubing in the well. A system for recording on a chart the time when the wave is initiated and the time when echoes return from obstructions in the well, serves as means to enable calculations to be made as to the depth to the obstructions.

The District Court found that patent 2,156,519 was an "improvement" patent (R. 28). Indeed, patent 2,156,519 itself acknowledges (R. 591, Col. 2, *l.* 14) the prior Patent No. 2,047,974 to Lehr and Wyatt, and states (R. 591, Col. 2, *ll.* 18-20) that it is an object of Walker's invention to improve upon the method disclosed in the Lehr and Wyatt patent.

Even prior to Lehr and Wyatt, it had been proposed to time echoes to measure distance in tubing. As early as 1898, in the patent to Batcheller No. 602,422 (R. 1065), it had been proposed to locate obstructions in this way. A gun K was fired into a tube J and the echo was detected and recorded by mechanism H (shown in detail in figure 4 of the patent) such as that commonly used in those days to make phonograph records.* In figure 5 (R. 1068) of the patent n^1 indicates the record made at the time the gun was fired and n^2 the record made on the return of the echo. The time required for the echo being proportional to the distance the sound traveled, the location of the obstruction could be calculated.

The Union Oil Company was the first to propose the use of this kind of apparatus for locating fluid levels in oil wells. In 1927 an apparatus for this purpose was built (R. 506). A gun was used to make a sound and a record of the time required for the echo to come back from the fluid in the well was made with ordinary electrical equipment consisting of a microphone, an amplifier and a motion picture camera recorder (R. 506-511).

Prior to November, 1933, the Shell Oil Company decided to use echoes to determine fluid levels in wells

---

*As shown in detail in figure 4 of the Batcheller patent (R. 1068):

"The sound-impulse-recording mechanism operates a light pivot-lever H, having at its end a stylus h. This lever, as shown, is pivoted to a frame H2, supported on the standard E2, the pivot being indicated at H1, a light spring H3 acting to press the lever H in one direction, as shown in Figs. 1 and 4, and an adjusting-screw H8 being provided as an abutment to prevent the movement of the lever H against the spring beyond a definite point. The lever is actuated by a connection H7, connected also to a diaphragm H6, which is secured to a block H4, hollowed out to form a chamber H5, into which opens a passage h4, or rather a tubular connection H11, screwing into the passage h4." (R. 1070).

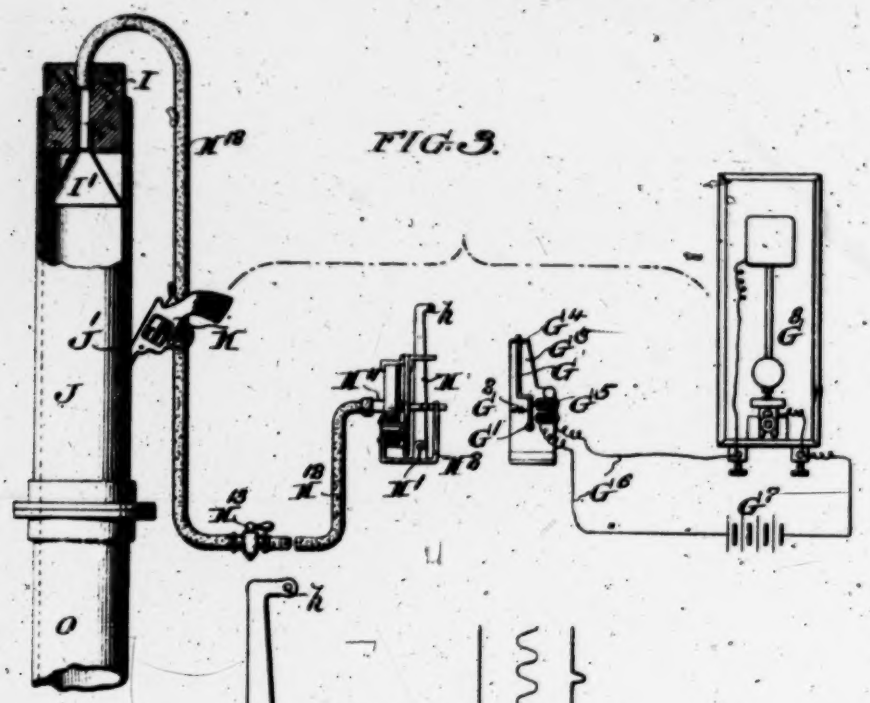
(No Model.) 2 Sheets—Sheet 2.

B. C. BATCHELLER.

APPARATUS FOR LOCATING OBSTRUCTIONS IN TUBES.

No. 602,422. Patented Apr. 19, 1898.

FIG. 3.


I
I'
J'
J
O
K
K'
K'
K'

(R. 245). Lehr and Wyatt were experienced oil men and employees of the Shell Oil Co. (R. 245, 250, 262). They had heard rumors about the work which had been done by the Union Oil Co. (R. 246, 247, 264). The Lehr & Wyatt patent acknowledges (R. 1103, Col. 1, *ll.* 10-27) prior attempts to measure depths of wells with sound waves. Lehr and Wyatt experimented with a gun and other sound producing devices (R. 264, 265), but they decided to use a pressure chamber instead of a gun for creating a pressure impulse. Lehr testified that a .38 caliber gun did not have enough energy to produce satisfactory results (R. 265, 266) and his patent states that the "sound method" is more or less unreliable (R. 1103, Col 1, *ll.* 41-42). A gun causes a "pressure impulse" as well as a sound (R. 336), but if gas is compressed in a cylinder and then liberated into the well through a quick-opening valve, the pressure impulse is much greater. "Compared with an impulse chamber, three pounds pressure * * * gave much more of a return than a .38 cartridge." (Lehr R. 265, 266). The Lehr and Wyatt patent suggests that the pressure in the chamber be 100 pounds per square inch (R. 1104, Col. 1, *l.* 40). The pressure impulse chamber is shown at 4 in the drawing (R. 1102) of the Lehr and Wyatt patent. When the valve 6 is opened, gas is admitted into the annular space between the tubing 8 and the casing 14 of an oil well and creates a pressure impulse, therein. This pressure impulse traveling at the same speed as that of sound (R. 338 goes down the well and echoes back. By observing the elapsed time for this impulse to traverse the space from the well head to an obstruction or liquid level in the well and return, the depth of the obstruction or liquid level can be determined.

The Lehr and Wyatt patent states (R. 1104, Col. 1, *ll.* 3, 4) that the elapsed time may be observed or indicated in any desired manner. As disclosed in Fig. 2 (R. 1102) one apparatus for making this observation is an ordinary microphone 15, provided with a suitable electrical amplifier 18 and a recorder 16. The recorder may be of a known type, in which a pen or pencil 21 runs on a recording drum 23 and is controlled by the circuit 17 from the microphone and amplifier. With such a device a record is made when the valve is opened to let the pressure impulse into the well and also when the echo returns from an obstruction in the well.

It is obvious and inherent in the Lehr and Wyatt device that if a partial obstruction in the well sends back an echo, that also will be recorded. Experiments conducted by experts in this art show that apparatus constructed in accordance with Figure 2 of the Lehr and Wyatt patent is operative to record fluid level in a well and also to record the level of other obstructions or partial obstructions, such as a tubing catcher or collars on tubing in the well. See Exhibits F, G, H and I (R. 885-889) and testimony thereon (R. 292, 293, 416-434).

The Novelty in the Patent in Suit

It is thus clear that the art was quite well developed by the time Walker entered the field. Walker was not a pioneer. As a matter of fact, he became interested in this art as the result of a demonstration to him by Lehr of the pressure impulse method of locating fluid level on one of the Shell Oil Company wells at Ventura, California, in October, 1935 (R. 154, 155, 514, 515). Walker adopted Lehr's pressure chamber with a quick-opening valve for

July 21, 1936. P. E. LEHR ET AL 2,047,974

METHOD AND APPARATUS FOR MEASURING WELL DEPTHS

Filed Nov. 1, 1933

Fig. 1

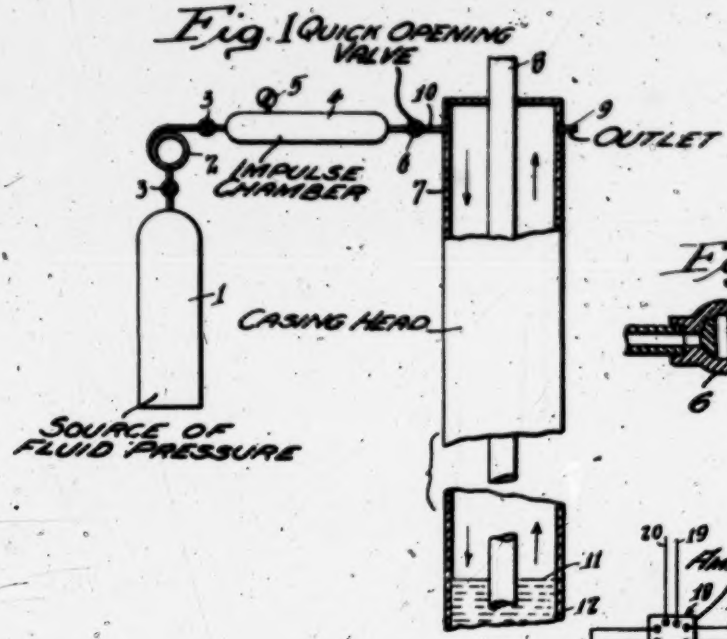


Fig. 4

Fig. 2

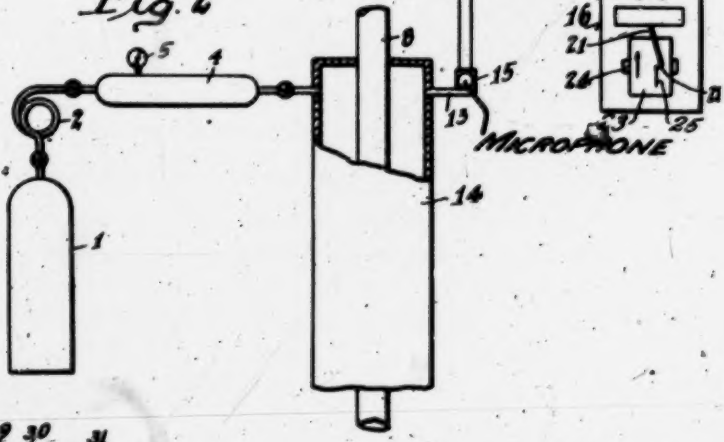
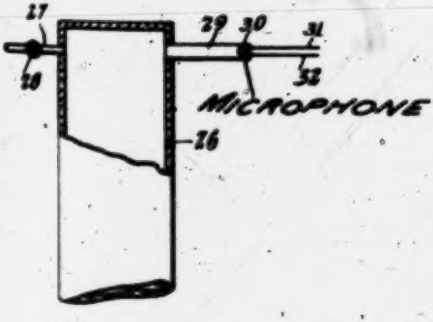


Fig. 3



Inventors

Harold S. Wyatt

Paul E. Lehr

By Lyon & Lyon

Attorneys

creating a pressure impulse in the well. Walker's improvement, found by the courts below to constitute invention, resides in the particular arrangement he proposed for recording the echoes from the well.

In the drawing of the Walker patent in suit (R. 588) the pressure impulse chamber is shown at 12, and the quick-opening valve at 16. These are connected to the well casing 4 by the coupling 19. The pressure impulse and its echoes are conveyed to the recording system by the pipe 18. The recording system includes a diaphragm 23 and a mirror 26, so that by the light beam 37 the pulses are recorded on a photographic film 39.

A mechanical diaphragm was old in an apparatus for recording echoes. That is what is disclosed in the patent to Batcheller 602,422 granted April 19, 1898 (R. 1068). Likewise, the use of a light beam and photosensitive film was old. See the patent to Taylor (R. 1096).*

Walker's system differs from the recorders of the prior art in the use of a pipe 18 of a particular length. There being nothing electrical about his recording system, Walker could not use an electrical amplifier such as that disclosed in the Lehr and Wyatt patent, to increase the intensity of returning signals, so he used an acoustical tuned resonator to amplify the echoes. The pipe 18, adjustable in length by the coupling 19, serves this purpose. The pipe 18 connects the housing for the pressure responsive diaphragm 23 to the well casing. The pipe can

*In the Taylor patent, movement of the mirror 11 is recorded on the film 2. Light from the lamp 12 is directed upon the mirror 11 and then through the optical system in the tube 5 to expose the film 2. (See specification R. 1097).

be "tuned" by adjusting its length to cause it to respond particularly to echoes from tubing collars. These echoes are then said to be "amplified," while echoes from other obstructions or partial obstructions are "damped out" (R. 595, Col. 1, *ll.* 48-71). The only novel element in the claims here in suit is the adjustable tuning pipe 18.* Both lower courts found the novelty in the patent to reside in the addition of this element to the Lehr and Wyatt system (R. 29, 1599, 1600). The District Court called it a "tuned acoustical resonator" (R. 29) and the Circuit Court of Appeals called it an "adjustable tuning pipe" (R. 1598).

While new in a device for recording echoes in wells, an adjustable pipe is not a novel means for causing a sound recorder to respond particularly to a certain frequency. In Fig. 17 of the patent to Tucker No. 1,451,356 (R. 1080), granted August 31, 1920, such a device is shown associated with a microphone connected to a system which may be recording.**

A tuned acoustical resonator was not even new with Tucker. His patent states (R. 1085, Col. 1, *ll.* 47-58):

> "The tuning of each combined unit of sound detecting device and acoustic resonator to a particular pitch may be either fixed or adjustable; in either case the tuning being attained in a well known manner by the proper adjustment of the shape, length, and volume of the resonating chamber, or of the aperture near the grid of the thermic sound detecting de-

*On the attached drawing of the patent in suit, we have circled the reference numeral 18 for emphasis, since the alleged invention resides in the use of this adjustable pipe.

**The Tucker patent shows only an indicator such as a bell F or lamp H, but on page 4 of the patent (R. 1086) *ll.* 18-20, it is stated that "it may be understood that any other indicating or recording device may be used instead."

ay 2, 1939. C. P WALKER 2,156,519

MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Filed Sept. 7, 1937 2 Sheets-Sheet 1

FIG. 1.

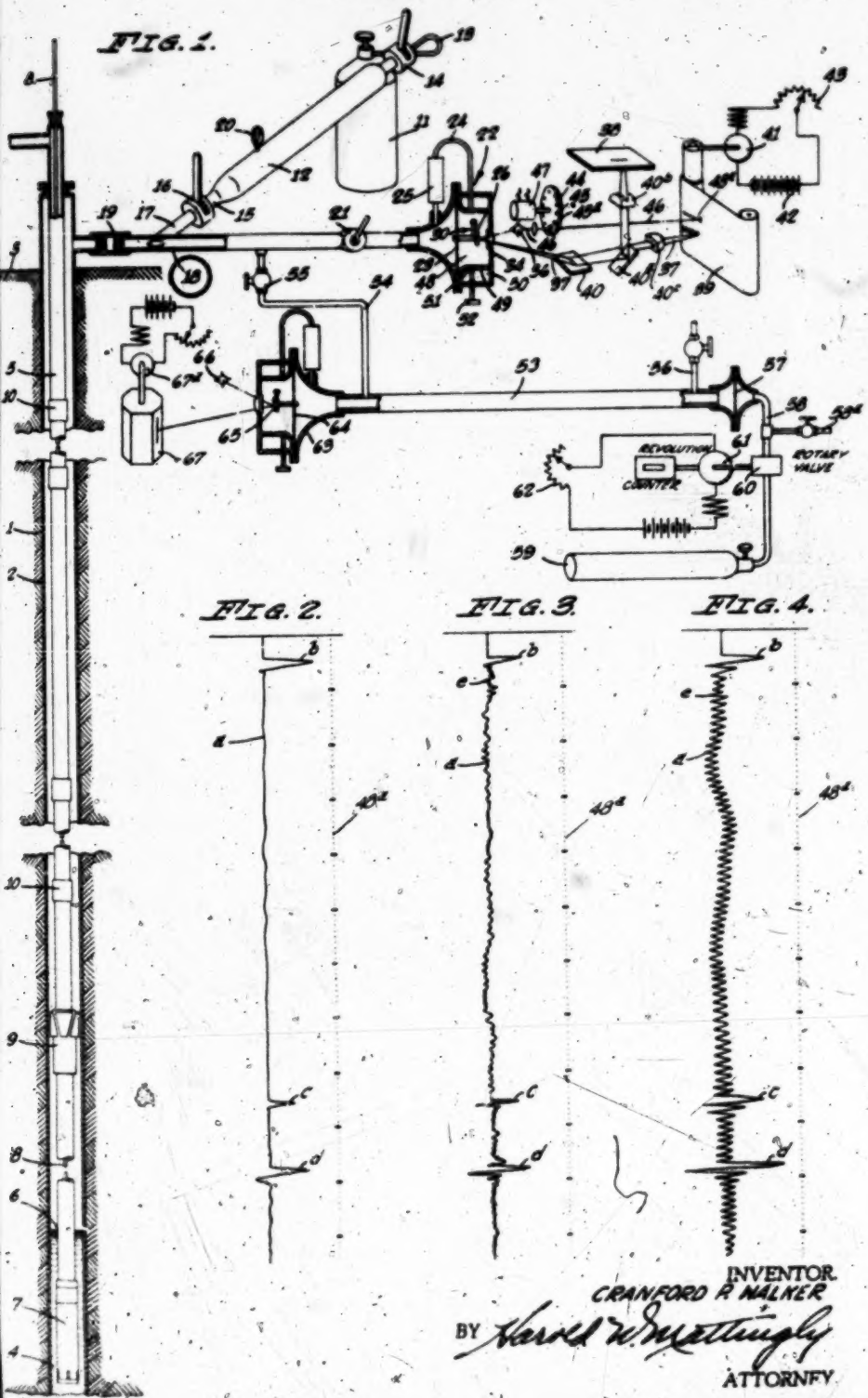


FIG. 2.

FIG. 3.

FIG. 4.

INVENTOR
CRANFORD P WALKER
BY Harold W. Hettinger
ATTORNEY

vice, or otherwise. Fig. 17 illustrates the method of tuning wherein the volume of the resonating chamber 1 is varied by a telescopic sliding movement."

Both of the lower courts have held, in effect, that invention is involved in substituting the recording system of the Tucker patent, which has an acoustical resonator, for the recording system of the Lehr and Wyatt patent, which has an electrical amplifier but does not have an acoustical resonator.*

The invention has been held to be of such a pioneer nature as to cover much more than this substitution, however. It has been held to cover an electrical recording system not disclosed or even hinted at in the patent. Petitioner's device has been held to infringe even though it has no acoustical resonator.

The Accused Device

In 1936, the Union Oil Company asked Dr. John J. Jakosky to develop the device that company had first experimented with in 1927 (R. 490, 491). The outcome was the apparatus known as the "Echo-Meter" (R. 491). Jakosky organized a company, International Geophysics, Inc., and for a time it provided the Echo-Meter service to the oil fields (R. 300). In May, 1940, the Petitioner, Halliburton Oil Well Cementing Company, purchased the business of International Geophysics, Inc., and rights under such patents as might issue thereon (R. 708).

---

*In *Altoona Pub. Theatres* v. *Am. Tri-Ergon Corp.*, 294 U. S. 477, 486, 79 L. Ed. 1005, 1011, it was held that selection of elements from the prior art to make a better sound record did not involve invention.

In developing the Echo-Meter, Jakosky selected only devices known in the prior art.* He employed neither the Lehr and Wyatt system nor the Walker improvements thereon. He used a gun to create a sound, whereas Lehr and Wyatt and also Walker had used a pressure impulse chamber; and he used a microphone, electrical amplifier and recorder to record the shot and echoes, whereas Walker had used a diaphragm recorder. The microphone selected was one known to be particularly suitable for recording gun shots. It consists merely of a grid of fine wire heated electrically, the wire being of such nature that its resistance varies greatly with temperature (R. 288, 289). A puff of air through the grid in either direction cools it and changes the resistance in proportion to the velocity of the air (R. 289). By recording the resistance of the grid a record of air movement is obtained (R. 289).

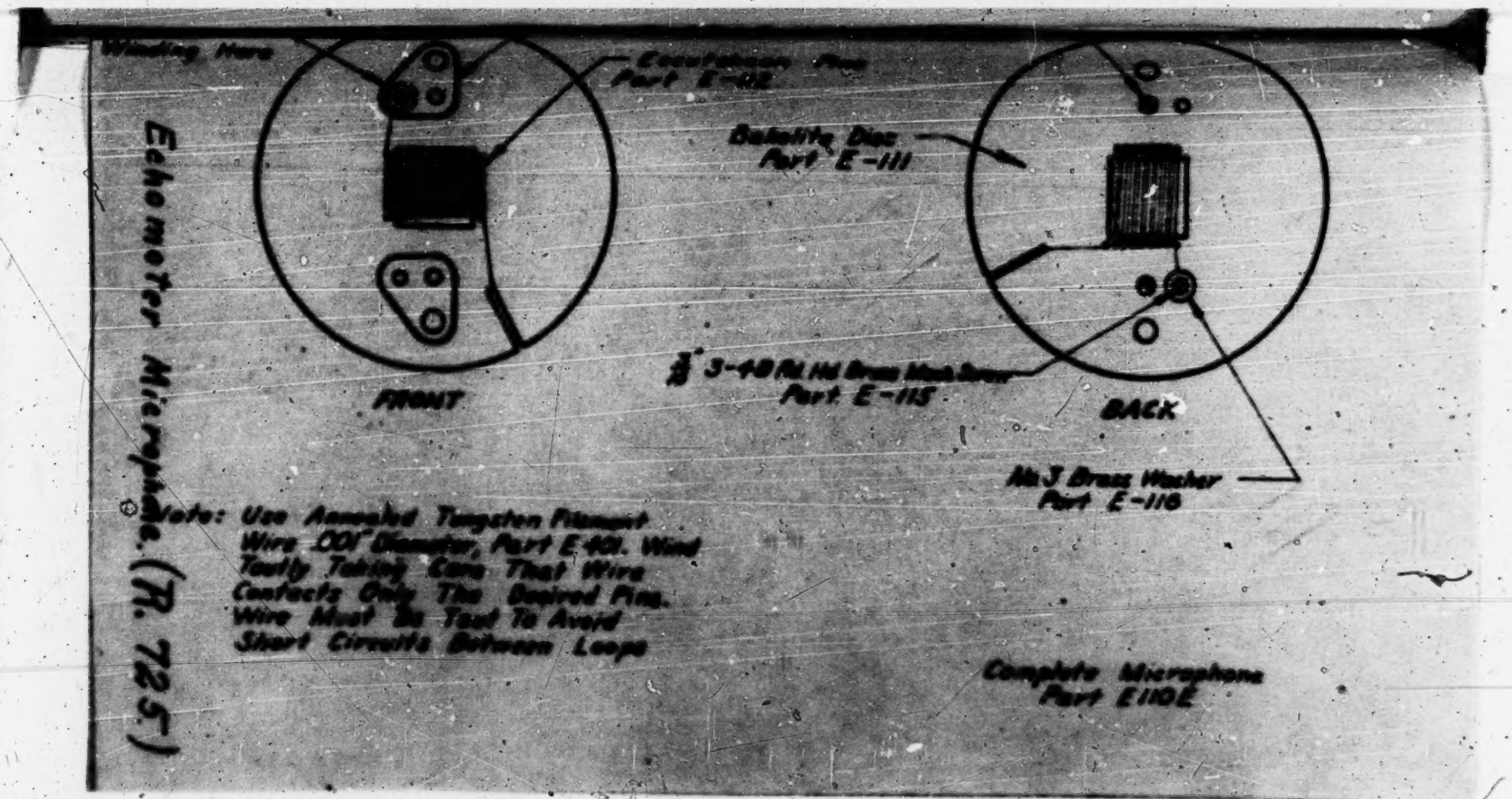
This microphone with an amplifier and a recorder was known (R. 392). It is described in U. S. Patent 1,351,356 to Tucker (R. 1077), granted August 31, 1920, for "Sound Detecting Device." It was also described by Tucker in a paper (R. 926), published January 5, 1923, before the Royal Society of Arts in London, entitled "The Hot Wire Microphone and Its Application to Problems of Sound." Tucker

---

*Jakosky had the right to work out another system for locating fluid levels by the use of echoes.

"All others have an equal right to make improved machines, provided they do not embody the same or substantially the same devices or combination of devices, which constitute the peculiar characteristic of the previous invention.* * *

"But it has been argued, that though not a colorable *invasion* of the pantentee's claim, it is an *evasion* of his patent, which is equally injurious. If so, it is '*damnum absque injuria.*' Every man has a right to make an improvement in a machine, and evade a previous patent, provided he does not invade the rights of the patentee."
Burr v. Duryee, 68 U. S. 531, 17 L. Ed. 650, 658, 659.



Echometer Microphone. (R. 725.)

W. S. TUCKER.

SOUND DETECTING DEVICE.

APPLICATION FILED JAN. 6, 1919.

,351,356.

Patented Aug. 31, 1920.

4 SHEETS—SHEET 2.

Fig.3.

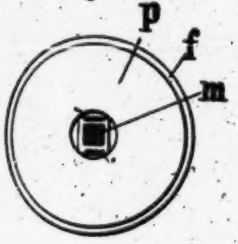


Fig.4.

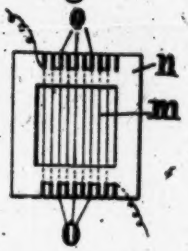


Fig.7.

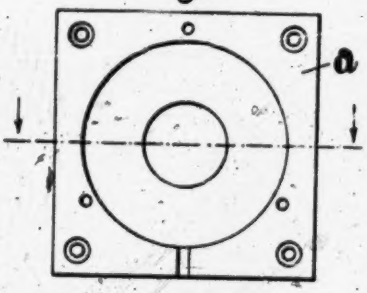


Fig.8.

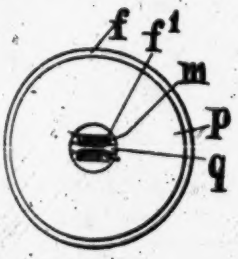


Fig.5.

Fig.6.

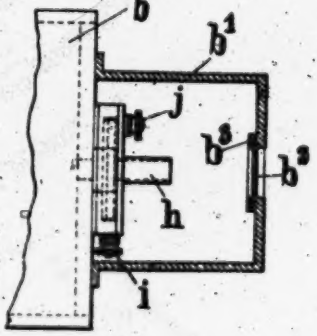


Fig.11.

Fig.9.

Fig.10.

Inventor
W. S. Tucker
By A. R. Kerslake
Atty

was a Major in the British Army and designed this microphone in 1918 to locate enemy gun positions (R. 387, 388, 926).

The Echo-Meter consists essentially of a gun using a .38 caliber blank revolver cartridge or a 10-gauge blank shot-gun shell (R. 288) mounted to discharge into a pipe connected to an oil well, and a Tucker hot-wire microphone to receive the echoes, the microphone being connected through a suitable amplifier, such as is commonly used in the radio art, to a recorder for making a record on a tape.* The technique and operation of the recording system are about the same as used by Tucker, except that Tucker used an acoustical resonator whereas the Echo-Meter does not. Some of Tucker's records appear in the Royal Society of Arts paper mentioned above (R. 927, 928, 930, 931). Commercial graphs made by Petitioner in the presence of Respondents (R. 280), are found in Exhibit D (R. 884). A graph made in court (R. 278) with a piece of hose simulating a well is found in Exhibit C (R. 883).

The Echo-Meter is used to locate obstructions and fluid levels in wells (R. 624). The records obtained show echoes from tubing collars, tubing catchers or other obstructions (R. 282, 285, 311, 313, 649). If the distance between tubing collars is known, or if the position of the tubing catcher is known, a comparison of echoes from

---

*The Echo-Meter is more fully described in the Field Manual (Ex 11-C, R. 719). Exhibits 12-B, 12-C and 12-D (R. 755-757) are photographs of Petitioner's device which was brought into court. The methods used in operating it are described by Cornes (R. 273 *et seq.*). See also Answers to Interrogatories (Exhibits 10, 11 and 12, R. 646, *et seq.*), particularly the Answer to Interrogatory 14, R. 653, and Exhibit 10-A, R. 713.

these known obstructions with the echo from the fluid level affords a basis for computing the distance to the unknown fluid level (R. 286, 287).

The Circuit Court of Appeals in its opinion (R. 1601) seems to assume, although it does not expressly state, that Petitioner's Echo-Meter produces the same result as that obtained by the patent in suit. While the records obtained with the Echo-Meter are used to determine fluid level, they are not the same as those obtained when using the apparatus of patent 2,156,519. The differences in result were fully explained at the trial by Walker (R. 173, 182, 183, 212, 213) by Dr. Mackeown (R. 341-343, 358, 361, 362, 365, 415), and by Cornes (R. 308, 309). The records are different because of the difference in structure of the devices, particularly the use of a hot-wire microphone instead of a diaphragm. The sketch (R. 781) shows the different kinds of records obtained by pressure and rarefaction waves with a "directional mike" or diaphragm, and a "non-directional mike," such as a hot-wire microphone (R. 212, 213). The diaphragm of the patent responds differently to positive and negative pulses, and because its "sensitivity of response" can be controlled (Patent 2,156,519, R. 593, Col. 1, *l.* 75), it makes a record on which each obstruction produces a "typical desired configuration" (*Idem*, R. 594, Col. 2, *l.* 24), so that one can "distinguish between echoes from different obstructions in the well" (*Idem*, R. 594, Col. 1, *ll.* 68, 69). All of the echoes recorded by Defendant's device are alike and are not distinguishable due to their configuration (R. 477-479). Defendant's microphone is not responsive to pressure (R. 341, 342, 343, 344, 358). It is

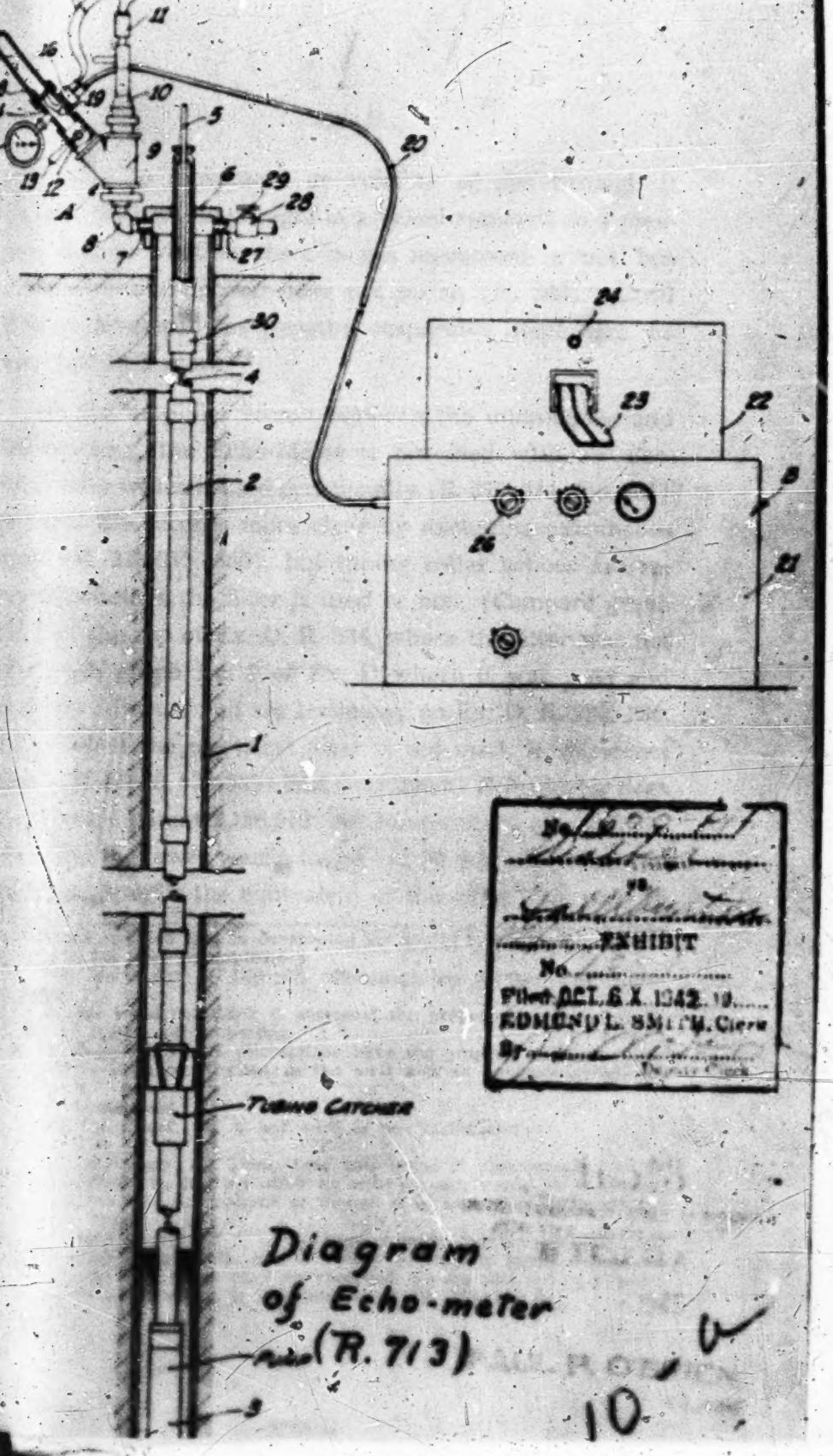


Diagram
of Echo-meter
(R. 713)

No. [illegible]
[illegible]
vs.
[illegible]
EXHIBIT
No. [illegible]
Filed OCT. 6 X 1942 19[illegible]
EDMUND L. SMITH, Clerk
By [illegible]
Deputy Clerk

10

responsive to movement or velocity of gas through it (R. 346, 658). A diaphragm in a vessel responds to a pressure change whether there is gas movement or not, but a hot-wire microphone does not do so (R. 360). Until Walker developed his pressure responsive diaphragm, he was "lost in a maze."*

In the amplifier circuit between the microphone and the recorder, the Echo-Meter is provided with an electrical filter which is used occasionally (R. 277, 314, 650, 651) to make the records more clear by excluding extraneous noise (R. 313-315, 650), but tubing collar echoes are recorded whether the filter is used or not. (Compare graph No. 1 at the top of Ex. D, R. 884, where the filter was not used with graph No. 2 of Ex. D where it was used and properly adjusted and see testimony on Ex. D, R. 282, 286, 287). When the electrical filter is not used, Respondents admit (R. 57, 58, 533-537) that Petitioner's Echo-Meter does not infringe patent 2,156,519, but Respondents contend (R. 534), and the lower courts found (R. 30, 31, 1603) that the electrical filter is the equivalent of the adjustable pipe 18

*Walker testified that in developing his device he discarded the idea of using a hot wire microphone.

"Mr. Mattingly: Q. Did you attempt to use the hot wire microphone?

"A. No, I did not think it possessed the proper characteristics. It had no directional properties. * * *

"Q. Does a hot wire microphone have the property of distinguishing between a constriction in the well and an enlargement in the well?

"A. It does not. * * *

"By the Court: Q. A hot wire is not (satisfactory)?

"A. It is not. * * *

"Mr. Mattingly: Q. Then these two types of obstructions, one of which constricts, and the other an enlargement; would be registered by the hot-wire microphone as though they were both constrictions, is that right?

"A. That is right. * * *. We have a large number of reflections from many of the wells, and if we are not able to identify those by the direction in which they are recorded, we are just lost in a maze; we don't know which is the fluid level" (R. 173-176).

of patent 2,156,519, and that claims 1, 13, 14, 15, and 17 of the patent define an electrical filter in calling for "means for tuning," etc.

Thus the holding of infringement of patent 2,156,519 is based on Petitioner's use of an electric filter in its Echo-Meter. A filter in an amplifying circuit is a common electrical expedient (R. 399, 651). It is an electrical device which controls the response of an amplifier (R. 350, 351) to eliminate extraneous noises. The filter contains resistance (R. 350) adjustable to reduce the gain in the amplifier of certain unwanted frequencies (R. 351, 363, 456). (See circuit diagram R. 734.)

Although the lower courts have held (R. 30, 1603) that a filter is the equivalent of an acoustical tuning device, there is no evidence whatever in the record supporting this holding. The uncontradicted expert testimony is that a filter is not even an electrical tuning device (R. 351, 356, 357). But electrical tuning devices are also old in the art. In fact, they are much older than filters (R. 352). In *Marconi Wireless Telegraph Co.* v. *United States*, 320 U. S. 1, 17, 30, 87 L. Ed. 1731, 1741, 1748, this Court found electrical tuning devices to be old in 1902. Filters were not developed until about 1916, but they had become quite common long prior to Walker (R. 352).*

*Dr. Mackeown testified:

"Resonant circuits are extremely old. The theory was first worked out by Lord Kelvin about 1850. A filter circuit is relatively new, and was first worked out by Dr. Campbell of the Bell Telephone Laboratories in 1916. They have been used very extensively by the Bell Telephone Company and make possible a communication of ten or twenty telephone communications over two wires, so that each party can communicate, and not be heard by the rest. That is entirely done by a filter. They are entirely different from the resonant or tuned circuits, which cannot be operated that way." (R. 352).

Filters had commonly been used in connection with amplifiers in electrical sound detecting systems. The patent to Williams No. 1,671,262 (R. 1089), granted May 29, 1928, shows a filter at 50 (R. 1090). The Williams patent states (R. 1092, *ll.* 21-25) that:

> "The present system while sensitive to very weak noises and signals is practically free from disturbances of the former, after the signals have been *filtered* and amplified."

Walker testified (R. 156) that in 1935 he decided to "take on the job of developing apparatus for the practice of the Lehr and Wyatt method." He investigated "devices on the market, microphones, amplifiers and electrical recording devices (R. 156, 157). The amplifier he purchased had a filter built into it. Walker testified:

A. "The amplifier that I used in making the records that have been submitted in evidence had a filter on it, a tone control, it is called in the ordinary radio outfit. This was used, I understand it, for recording heart beats and had a filter on it which I used in my experiments, but it did not have much effect.

Q. What date are you referring to?

A. I am referring to experiments in the early part of November.

Q. What year?

A. 1935; November 13th to along towards the latter part of the month.

Q. That apparatus, was that an apparatus that had a microphone and an oscillograph in this recording circuit with the amplifier?

A. That is correct.

Q. That filter was a low pass, a low frequency filter; it was not a resonant tuned circuit, was it?

A. I do not know, Mr. Babcock, just what type of filter it was.

Q. Was it the type of filter that is shown and described in your patent application, now offered as defendant's Exhibit L.

A. I have just testified that I did not know what type it was. I did not make a very close examination of it, so I therefore can't make any comparison between the two." (R. 516).

Anyone skilled in the art, in attempting to build apparatus in accordance with figure 2 of the Lehr and Wyatt patent would just as naturally have selected such an amplifier. The Lehr and Wyatt patent states that an amplifier may be used. It does not specify what kind of amplifier, but one skilled in the art would certainly know enough to purchase an amplifier "on the market."

We submit that the Wyatt and Lehr patent *per se* teaches the use of a filter in the amplifier of an electrical recording system. If this patent alone is not sufficient to teach this, then the other prior art, such as the Williams patent, shows there is no invention in such use. If the claims of the Walker patent in suit are so broad as to cover such use, they should be declared invalid. As will be shown presently, the Examiner in the Patent Office in charge of the art of Electric Signaling, refused to grant claims to Walker on exactly this combination.

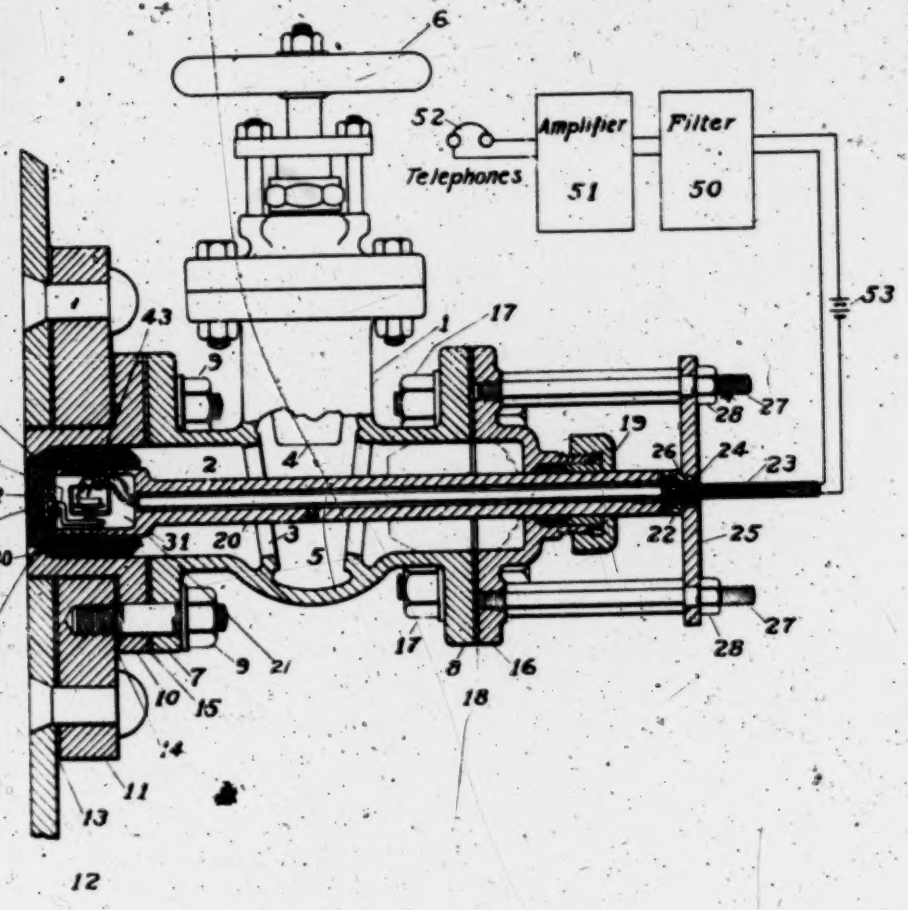
y 29, 1928.

1,671,262

R. L. WILLIAMS

SUBMARINE SOUND RECEPTION

Filed April 2, 1925



INVENTOR.

ROBERT L. WILLIAMS

BY Ezekiel Wolf

Analysis of the Claims in Suit

Claims 1, 13, 14, 15, and 17 of patent 2,156,519 are in suit. These claims use different language, but all are similar in construction, so only claim 1 will be analyzed specifically. In the introductory part, this claim (R. 596) calls for apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein interconnected with each other by coupling collars. The Lehr and Wyatt patent (R. 1101) shows an oil well with tubing 8 therein. The Lehr and Wyatt device was used in wells having tubing therein and the tubing had collars (R. 271). Therefore, there is no novelty defined in this part of the claim. The claim then calls for "means for creating a pressure impulse in the well." This is the same device as that of the Lehr and Wyatt patent—a pressure impulse chamber and valve.* The claim further calls for "echo receiving means including a pressure responsive device exposed to said well for receiving pressure impulses from the well." The pressure responsive device is the diaphragm 23 and associated parts. There is no dia-

*The patent excludes the use of a gun by calling for an arrangement by which pressure pulses can be adjusted and by making a distinction between sound methods and pressure impulse methods. See testimony of Dr. Mackeown (R. 470-471). In setting forth the objects of the invention (R. 591), a careful distinction is made in the patent between the use of low energy sound waves and high intensity impulses produced by the Lehr and Wyatt pressure chamber. Respondents cannot now turn around and say that the use of sound waves as taught by Batcheller is an infringement of the claims. *Weber Electric Co.* v. *Freeman Electric Co.*, 256 U. S. 668, 65 L. Ed. 1162. Such expansion of claims is "an evasion of the law." *White* v. *Dunbar*, 119 U. S. 47, 30 L. Ed. 303, 305.

phragm in the Lehr and Wyatt patent, but there is no invention in its use instead of a microphone, because Batcheller (R. 1065) shows a diaphragm.*

The final clause of the claim defines the only element alleged to be novelty, and the only element found by the courts below to be novel (R. 29, 1599, 1600). It calls for "means associated with said pressure responsive device for tuning said receiving means to the frequency of echoes from the tubing collars." *The entire novelty of the alleged invention is defined simply as "means" for accomplishing the desired function.* What this "means" is, how it operates, or how it co-operates with the other parts of the apparatus is not defined. Walker has added a resonance pipe to the Lehr and Wyatt system, but he seeks a monopoly on all means for tuning a receiver in such system.

The other claims in suit use the same kind of language to define the alleged novelty. The clause of claim 13 (R. 597) which is supposed to define invention over the Lehr and Wyatt patent reads: "means associated with said receiving and registering means to accent the registration of tubing coupling echoes." The word "accent" does not even appear in the specification. Claim 14 (R. 598) defines the allegedly novel structure as "interference eliminating means." This phrase does not appear in the specification. The claim recites that this "means" is to limit the response of the receiver to echoes from "actual" obstructions. The significance of the word "actual," is not explained in the

*If the claim is interpreted to limit this phase to definition of a diaphragm, together with the particular mounting for the diaphragm as we think was intended by Walker when it was drawn, then clearly there is no infringement, for Petitioner, like Wyatt and Lehr, uses a microphone.

specification. The claim does not define structure for eliminating the recording of all other than actual obstructions. It merely calls for "means" for doing so. Likewise, claim 15 (R. 598) defines the alleged novelty over Lehr and Wyatt as "resonance means * * * to produce therein a natural acoustical period of oscillation," and claim 17 (R. 598) calls for "means having a natural frequency of oscillation * * * to accent" echoes from "couplings and other obstructions." The word "resonance" does not appear anywhere in the specification, nor does the phrase "natural acoustical period of oscillation."

All of these phrases no doubt refer to the pipe 18 of adjustable length connecting the receiver to the well casing. There is no basis for assuming that in drawing these claims Walker intended to cover the use of an electrical filter in the Lehr & Wyatt recorder or that the Patent Office intended to grant Walker a monopoly on such use. Claim 15 of patent 2,156,519 (R. 598), for example, shows that there was no such intention. The claim employs both the word "resonance" and the word "acoustical" to describe the "means." The word "resonance," while used in electricity to define intensification of a particular frequency, is more commonly used to define intensification of sound. The word "acoustical" is not an electrical term at all.* Acoustics is "the science of sound, including its production, transmission and effects." *(Webster's New International Dictionary,* 2nd Ed., 1938)

---

*"The Court: When you say 'experimenting with acoustical tuning,' you mean mechanical tuning? A. Mechanical tuning, that's right, your Honor." Walker (R. 517).

Dr. Mackeown, professor of electrical engineering in the California Institute of Technology and in charge of the work there in radio, sound recording, electronics, etc. (R. 327), testified that an electrical filter is not a tuning device (R. 446, 447), is not resonant, even electrically (R. 362, 363, 364, 446), does not have a "natural frequency of oscillation" (R. 362, 457, 458) and does not amplify (R. 363, 364). It does not operate on the same principle as an electrical tuning device (R. 363, 364) and has nothing in common with a tuned pipe (R. 350, 353, 356). There is not one word of testimony anywhere in the record in contradiction of Dr. Mackeown's statements; nor is there one word of testimony anywhere in the record in contradiction of his testimony that an electrical filter has an entirely different mode of operation than an acoustically tuned pipe (R. 356). The Circuit Court of Appeals, in holding (R. 1603) that an acoustically tuned pipe is the equivalent of an electrical filter, quoted (R. 1603) statements of the Patent Office Examiner. We submit that consideration of the Examiner's statements for this purpose was improper. Proceedings in the Patent Office cannot properly be used to expand the claims of a patent. They can be used only to limit the claims. *Dwight & Lloyd Sintering Co.* v. *Greenawalt*, 27 Fed. (2d) 823, 832, (C. C. A. 2).

> "Under the statute it is the claims of the patent which define the invention."
>
> —*Altoona Pub. Theatres* v. *Am. Tri-Ergon Corp.*, 294 U. S. 477, 487, 79 L. Ed. 1005, 1012.

The quoted statements of the Examiner were made in the copending application Serial No. 164,534 (Exhibit L, R. 953), after patent 2,156,519 had issued. The first part of the quotation in the Court's opinion was made March 29, 1941 (R. 1045-1047), and the quotation as to equivalency was made April 11, 1942 (R. 1056, 1060). Neither statement was made by the Examiner who issued patent 2,156,519. The statement as to equivalency was made after this suit had been filed and after counsel for Respondent had practically insisted that the Examiner make such a statement (See, for example, Walker's "Request for Further Explanation" of April 6, 1942. R. 1058, 1059). After patent 2,156,519 had issued, statements by an Examiner in another case are extrinsic and irrelevant on the question of the scope of the claims. Petitioner had no chance to cross-examine the Patent Office Examiner as to these statements. They are not sworn testimony and cannot properly be used to rebut the sworn testimony in this record. The statements were not made as an interpretation of the claims here in suit, but were made as an additional ground for refusing claims in application Serial No. 164,534. The statement as to equivalency was supported by an additional reference, a patent to Holland granted in 1924, showing electrical tuning. (See full statement of the Examiner, R. 1060). If the use of a filter was known, as this Examiner had previously stated (R. 1002), and if it is the equivalent of an acoustical tuned resonator, then Walker made no invention over Lehr and Wyatt in the first place.

Regardless of expert opinion, the patent grant itself precludes such broad interpretation. As has often been

said, a patent is a contract.* Consideration for the grant is the disclosure to the public of "some substantial innovation." *Sinclair and Carroll Co., Inc.* v. *Interchemical Corp.*, — U. S. —, case No. 656, October Term, 1944, decided May 21, 1945. There being no suggestion whatever in patent 2,156,519 of the use of an electrical filter, the specification and claims should not be construed to cover such use.

Disclosure of one device does not constitute consideration for a monopoly on an entirely different device.

> "The thing patented is the particular means devised by the inventor by which that result is attained, leaving it open to any other inventor to accomplish the same result by other means."
>
> —*Electric R. R. Signal Co.* v. *Hall Railway Signal Co.*, 114 U. S. 87, 29 L. Ed. 96, 99.

See also *Corning* v. *Burden*, 56 U. S. 252, 14 L. Ed. 683; *Fuller* v. *Yentzer*, 94 U. S. 288, 24 L. Ed. 103.

Proceedings in the Patent Office

Had Walker intended to have patent 2,156,519 cover the use of an electrical filter in the Lehr and Wyatt system, it would have been a simple matter to disclose that device in the specification. Walker had used an electrical filter in the echo recording system he had built to test out the Lehr

---

*The specification and claims of a patent constitute the patent contract. *O. H. Jewell Filter Co.* v. *Jackson*, 140 Fed. 340 (C. C. A. 8); *Firestone Tire & Rubber Co.* v. *U. S. Rubber Co.*, 79 Fed. (2d) 948 (C. C. A. 8), (cert. den. 298 U. S. 679).

A patent is a contract between the inventor and the government and is subject to the same general rules of construction that apply to other contracts. When its terms are plain, and the intention of the parties clearly manifest therefrom, they must prevail. *Goodyear Dental Vulcanite Co.* v. *Davis*, 102 U. S. 222, 26 L. Ed. 149.

and Wyatt system in 1935 (R. 516). His conception of the idea of using an acoustical tuned pipe did not take place until March 6, 1937 (R. 196). Instead of making disclosure of electrical means in the application for patent 2,156,519, he filed a separate application on the electrical system with an electrical filter "for tuning" the electrical circuit to cause it to "respond more readily to echoes from selected obstructions" in the well, (quoting from claim 15, R. 982), this application being Serial No. 164,534 (Exhibit L, R. 954). This application was filed September 18, 1937, only eleven days after application for patent 2,156,519 was filed.

The two applications were handled by different Examiners in the Patent Office. The application for the patent in suit went to Division 5, Class 181-0.5 (R. 1416), "Acoustics, Miscellaneous." Apparently, the Examiner in Division 5 made no search in the electrical signaling art. Neither the Tucker patent* (R. 1077) showing the acoustical resonator, nor the Williams patent (R. 1089) showing an electrical sound detecting system having a filter connected to an amplifier, nor any similar prior art, was cited.

The co-pending application Exhibit L, on the other hand, was examined in Division 42, Class 177 (R. 990), "Electric Signaling."

---

*The Circuit Court of Appeals, in its opinion, stated (R. 1600):

"The Tucker patent mentioned was among the examples of the prior art cited by the Examiner."

The Court was in error. The Tucker patent was not cited. The only prior patents cited were Batcheller 602,422, Taylor 1,847,336, and Lehr and Wyatt 2,047,974. See rejections (R. 1464, 1482).

The co-pending application contained the following claim:

> "15. In a system for receiving and translating pressure echoes for various obstructions in a well, pressure responsive means coupled to the well to be exposed to pressure variations therein, electrical means actuated by said pressure responsive means to vary electrical values in accordance with the variations of pressure received by said pressure responsive means, translating means for receiving said electrical variations and for describing an observable wave pattern corresponding to the patterns of the echo waves, and means interposed between said pressure responsive means and said translating means for tuning said electrical means to respond more readily to echoes from selected obstructions than to pressure variations emanating from other sources." (R. 982)

Had the Patent Office intended to grant Walker a monopoly on a system having an electrical recorder with electric tuning, this claim would have been allowed. Instead of allowing it, on April 5, 1939, which was prior to the issuance of patent 2,156,519, the Patent Office Examiner in Division 42 rejected this claim on the prior art.* The Examiner's rejection included the following:

---

*In its Petition for the Writ of Certiorari herein, page 3, Petitioner stated that claim 15 (R. 982) of the co-pending application Serial No. 164,534, was rejected (R. 1002) as involving no invention over the prior art and canceled (R. 1003). Respondents, in their Brief in Opposition to the Granting of the Writ, page 11, stated:

"What petitioner fails to say is that in the instant case, *there was no prior art upon which the electrical claims could be rejected* except Walker's own patent in suit." (Italics theirs).

Respondents' statement is not true. Claim 15 of application 164,534 was rejected on the prior Lehr and Wyatt patent in view of a prior patent to Rieber (R. 1000) and again on the Lehr and Wyatt patent alone (R. 1002). It was never rejected on the Walker patent in suit. The patent in suit had not yet issued when these rejections were made.

"Claim 15 is further rejected on Lehr *et al* alone. This claim differs from the reference only in the inclusion of a filter. But it is not invention broadly to use a filter wherever a filter is desirable" (R. 1002).

In response to this rejection, Walker cancelled claim 15 (R. 1003).

This cancelled and abandoned claim 15 reads squarely upon Petitioner's Echo-Meter, if the interpretation of the terms of the claims in suit by the Circuit Court of Appeals is correct. The "pressure responsive means" is the Y-pipe, the housing and the microphone coupled to the well. The "electrical means actuated by said pressure responsive means" is the amplifier. The "translating means" is the electrical recorder. The "means for tuning" is the filter.

Unless the decision of the Circuit Court of Appeals is modified, Petitioner will be enjoined from doing the thing that the Patent Office records show is permissible as outside the scope of the monopoly the Patent Office intended to grant Walker.

The file wrapper of patent 2,156,519 itself (Exhibit T, R. 1415) shows that there was no intention on Walker's part, or on the part of the Patent Office, to cover anything electrical in the claims.

The rejections (R. 1464, 1482) by the Examiner were chiefly based on the prior patents to Batcheller and Lehr and Wyatt. Counsel interviewed the Examiner several times (See reference to the interviews, R. 1498, 1512, 1531),

and argued extensively (R. 1498-1535) that invention was involved in the Walker system because it made records by which echoes from different obstructions were "distinguishable" (R. 1500). It was argued that the prior art devices were incapable of doing so (R. 1503, 1504).

The claims here in suit (R. 596-598) are claims 1, 13, 14, 15 and 17. These were presented late in the prosecution of the application. They were originally numbered 52 (R. 1496), 58 (R. 1528), 59 (R. 1529), 60 (R. 1529), and 62 (R. 1530), respectively. All were added by amendment after the rejections of earlier claims on Batcheller and Lehr and Wyatt. The claims here in suit define one of the elements as a "pressure responsive device," or a similar term. According to the specification (R. 592, Col. 1, *ll.* 26-28) the "pressure responsive device" is the apparatus shown in Figure 5 (R. 590). It includes the diaphragm 23 and the associated housing and other parts. Page 4 of the specification (R. 594, Col. 1, *l.* 63 *et seq.*) describes how this apparatus may be adjusted to vary the sensitivity of the diaphragm 23 and thus "distinguish between echoes from different obstructions in the well" (R. 594, Col. 1, *ll.* 68, 69). The prior patents to Batcheller, while it had a diaphragm, did not disclose a pressure responsive device capable of being adjusted to accomplish this function. (See argument of counsel R. 1476, 1477).

Original claim 20 (R. 1451) did not include a "pressure responsive device." This claim was cancelled and claim 53 (R. 1497), which called for a "pressure responsive device" was substituted therefor. Claim 53 in turn

was cancelled (R. 1528) when claims 58 to 62 were added, these being re-numbered 13 to 17 when the patent issued. It is clear therefore that this phrase as used in the claims defines something more than the simple diaphragm of Batcheller or an ordinary microphone such as disclosed in the Lehr and Wyatt patent. Only by ignoring the file wrapper can the phrase "pressure responsive device" be construed to define a hot-wire microphone. By adjusting Respondents' "pressure responsive device," slow or gradual changes in pressure can be recorded. A slow change in pressure would have no perceptible effect on an Echo-Meter record (R. 360). The hot-wire microphone responds only to a quick change in velocity—a "steep-front sound wave" (R. 623) such as that created by a gun shot.

In another respect, the file wrapper (Exhibit T, R. 1415) of the patent in suit imposes limitations in the claims in suit.

Broad claims (such as original claim 27, R. 1454), not limited to tuning had been rejected (R. 1464) on Batcheller (R. 1065), and cancelled (R. 1466). In presenting claims 52, 58, 59, 60 and 62 (claims 1, 13, 14, 15 and 17 of the patent), it was represented to the Patent Office that the language of claim 58 specifies "all of the necessary elements for accomplishing the result of producing the echoes from the tubing collars which are distinguishable from each other" (R. 1532); that "claim 59 recites the same structure in more limited terms, specifying that this means or mechanism for permitting the distinguishable registration of the tubing collar echoes is an 'interference eliminating

means' * * * as specified on page 20 of the original specification" (R. 1533); that "claim 60 defines the same subject but limits the mechanism to a resonance means, which produces a natural acoustical period of oscillation" (R. 1533), that claim 62 is directed to the feature "which has the peculiar characteristic that it has the natural frequency of oscillation which will result in the accenting of tubing collar echoes" (R. 1533), and claim 52 (claim 1 of the patent) was classed with claims specific to an adjustable pipe, counsel stating:

> "Upon review of Claims 24, 25 and 26, it is believed that these claims are rendered more accurate and definite by employing the word 'effective' to *define the adjustment of the length of the pipe or other coupling means employed to tune the receiving means to the tubing collar echoes.** This amendment does not change the subject matter defined by these claims and it is believed that each of them is clearly allowable over the references of record.
>
> "Claims 52 and 57 are likewise directed to *this same subject matter* but expresses the invention in somewhat different terms. Again, however, these claims are directed to the feature of producing distinguishable tubing collar echoes and are believed to be clearly patentable over the references of record." (R. 1533, 1534).

The Court may properly consider "what the patentee said when he was making his application" to determine whether "the construction of the patent is confirmed by the avowed understanding of the patentee expressed by

---

*Throughout this brief where italics appear in quotations, the emphasis has been supplied by us unless otherwise indicated.

im, or on his (be)half, when his application for the orig-
nal patent was pending." *Goodyear Dental Vulcanite Co.* v.
Davis, 102 U. S. 222, 26 L. Ed. 149, 150.

If the file wrappers (Exhibit T, R. 1415 and Exhibit L,
. 953) are considered, it becomes clear that the patent in
uit is directed to a system quite different from Petitioner's
Echo-Meter.

It was old in the art to shoot a gun and record the
cho with a diaphragm recorder (Batcheller, No. 602,422,
. 1065). It was old in the art to create a pressure impulse
n a well by allowing gas to enter from a pressure cylinder
nd record the echo with a microphone, amplifier and
lectrical recorder (Lehr, No. 2,047,974, R. 1101). From
he prior art, Walker selected the pressure cylinder of Lehr
nd the diaphragm recorder of Batcheller, and added an
djustable pipe to tune the recorder. Petitioner went just
he other way. It selected the gun of Batcheller, the micro-
hone of Tucker, and used the conventional electrical am-
lifier and recorder, such as disclosed in the Lehr patent
nd used by the Union Oil Company long before that.
Where such differences exist between the structure of a
atent, and the structure of the accused device, no in-
ringement exists. *Electric R. R. Signal Co.* v. *Hall Railway*
ignal Co., 114 U. S. 87, 29 L. Ed. 96.

SUMMARY OF ARGUMENT

The claims in suit are invalid.

The Circuit Court of Appeals for the Ninth Circuit, by ruling that "means * * * for tuning * * *" in Claim 1 and like functional statements in Claims 13, 14, 15 and 17 of Patent 2,156,519 define the only novel element in the claims "with sufficient distinctness and clarity to comply with the statute" (R. 1600), has rendered a decision in direct conflict with the decision of this Court in *General Electric Co. v. Wabash Appliance Corp.*, 304 U. S. 364, 82 L. Ed. 1402. The claims do not meet the requirements of R. S. Sec. 4888.

The claims in suit are not infringed.

The Circuit Court of Appeals for the Ninth Circuit, by ignoring the rejection, cancellation and abandonment of a claim in a co-pending application for patent, has so construed the claims in suit as to cause them to cover subject matter refused Respondents by the Patent Office and has imposed undue restrictions on the rules governing the construction of claims set forth in *Schriber-Schroth Co. v. Cleveland Trust Co.*, 311 U. S. 211, 220, 221, 85 L. Ed. 132, 137, 138. Respondents are estopped from asserting title to the abandoned subject matter.

Conclusion

Respondents seek a monopoly on apparatus entirely different than that disclosed or intended to be covered by the patent grant. The claims of the patent should be held invalid because broader than the invention. If valid, they should be held not infringed by apparatus different from that disclosed in the patent.

ARGUMENT

The claims in suit are invalid.

The requisites for definiteness in the specifications and claims of a patent are statutory. Section 4888 of the Revised Statutes (U. S. C. title 35, sec. 33) requires that a patentee describe his invention in:

> "* * * such *clear, concise and exact terms* as to enable any person skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct, compound and use the same; and in the case of a machine, he shall *explain the principle thereof,* and the best mode in which he has contemplated applying that principle, so as to *distinguish it from other inventions;* and he shall *particularly point out and distinctly claim* the part, improvement or combination which he claims as his invention or discovery."

> "It seems to us that nothing can be more just and fair both to the patentee and to the public, than that the former should understand and correctly describe just what he has invented, and for what he claims a patent."
>
> —*Merrill* v. *Yoemans,* 94 U. S. 568, 24 L. Ed. 235, 237.

> "The statute requires the patentee not only to explain the principle of his apparatus and to describe it in such terms that any person skilled in the art to which it appertains may construct and use it after the expiration of the patent, but also to inform the public during the life of the patent of the limits of the mon-

opoly asserted, so that it may be known which features may be safely used or manufactured without a license and which may not."

—*Permutit Co.* v. *Graver Corp.*, 284 U. S. 52, 60, 76 L. Ed. 163, 167.

"The courts in determing the questions of invention and infringement brought to them by respondent, no less than the parties-litigant, need and may insist upon the precision enjoined by the statute."

—*United Carbon Co.* v. *Binney & Smith Co.*, 317 U. S. 228, 232, 87 L. Ed. 232, 235.

The Circuit Court of Appeals seems to have set up a rule for testing the definiteness of claims to a combination different from that applicable to claims for a single element or specific product. In denying the petition for rehearing, the Court stated:

"In its petition for rehearing appellant, Halliburton Oil Well Cementing Company, assumes that the court in ruling on Walker's patent No. 2,156,519 failed to consider the cases of *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, and *Davis Sewing Mach. Co.* v. *New Departure Mfg. Co.*, 217 Fed. 775, particularly the first of these decisions. Halliburton is mistaken. In the General Electric case the claim considered was not one for a combination of elements, but a claim for a single element. Here, the claims are for a combination of elements." (R. 1614)

In his concurring opinion denying rehearing, Judge Denman stated:

"No case is cited in which such a combination of means alone has been sought and the case seems of novel import." (R. 1615)

We believe there is no previous authority for the distinction made by the Court. Certainly the statute does not authorize such a distinction. In fact, the statute seems to require even greater particularity in a patent on a machine than in a patent on one of the other three classes of inventions listed as patentable in R. S. 4886, (U. S. C. title 35, sec. 31), for R. S. 4888 mentions it specially, stating:

"and in the case of a machine, he shall explain the principle thereof, and the best mode in which he has contemplated applying the principle, so as to distinguish it from other inventions."

"The term 'machine' includes every mechanical device or combination of mechanical powers and devices to perform some function and produce a certain effect or result."

—*Corning et al*, v. *Burden*, 56 U. S. 252, 267, 14. L. Ed. 683, 690.

The claims involved in *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, would not have been rendered more definite if they had called for a *combination* of the old parts of the lamp with the new filament instead of calling for "a filament *for* electric incandescent lamps."

Conversely, there is no real difference between the claims in the present case for a *combination* of parts of the old Lehr and Wyatt device with means for tuning one part, and a claim directed merely to means *for* tuning the receiver of the Lehr and Wyatt device.

The requirements for definiteness should not be evaded by reciting inconsequential matter in a claim. All Walker has added to the Lehr and Wyatt system is the acoustically tuned pipe. This does not affect the "means communicating with said well for creating a pressure impulse in said well" (referred to as element B by Judge Denman, R. 1615).

> "The improvement of one part of an old combination gives no right to claim that improvement in combination with other old parts which perform no new function in the combination."
>
> —*Lincoln Engineering Co.* v. *Stewart-Warner Corp.*, 303, U. S. 545, 549, 550, 82 L. Ed. 1008, 1010.

If there is a difference of any importance between the form of the claims in the Walker patent in suit and those condemned in *General Electric Co.* v. *Wabash Appliance Corp.*, it is a difference which brings the claims in suit squarely within the ruling in *Lincoln Engineering Co.* v. *Stewart-Warner Corp.* The claims are to an old combination.

But the use of the word "means" to define the novel element in combination claims does not raise a question of novel import. In 1907, in the case of *Tyden* v. *Ohio Table Co.*, 152 Fed. 183, the Circuit Court of Appeals for the Sixth Circuit had before it a patent on a pedestal table. Claim 1 of the patent was for a combination of elements. The parts of the table were set forth in some detail, but the novel element was defined only by the word "means" followed

by a recital of functions. The Court, speaking through Judge (afterwards Mr. Justice) Lurton, held that the claim was too broad, stating:

> "It claims all means for locking and holding the pedestals and is substantially a claim for a function. It cannot be upheld and must be held void."

Later, the rule of *Tyden* v. *Ohio Table Co.*, was again considered by the Circuit Court of Appeals for the Sixth Circuit. In *Davis Sewing Machine Co.* v. *New Departure Mfg. Co.*, 217 Fed. 775, combination claims, which used the word *"mechanism"* instead of *"means"* to define certain elements, were under consideration. It was held that such broad terms were not objectionable where used in the claim to define other than the novel element, but the soundness of the decision in *Tyden* v. *Ohio Table Co.*, was not questioned where the functional clause was used to define the exact point of novelty. The opinion by Judge Denison states:

> "Reliance is also placed upon the opinion of this Court, speaking by Judge (afterwards Mr. Justice) Lurton, in *Tyden* v. *Ohio Table Co.*, 152 Fed. 183, 81 C. C. A. 425. In this case, the claim calling for 'means' was held invalid because it covered all means for accomplishing the result, and so was functional. We do not question the application of the rule as made to the facts of that case; but we do not understand that a claim is functional and invalid merely because one of its specified elements is 'means,' as in the Tyden Case, or 'mechanism,' as in the present case. This result may or may not follow, depending upon whether the all-inclusive term is used with reference to the ele-

ment or subcombination which is *the real point and gist of the invention*, or *whether it is used with reference to elements or parts of the combination already well known* and designed only to co-operate with the new element in order to make a completely operative unit. In other words, *where used with reference to the exact point of novelty*, 'means' or 'mechanism' *may expose the claim to attack* on the ground that it is functional; in that respect, each case will present a problem by itself. But where used with reference to the make-up of the field in which the real invention finds its usefulness or with reference to the connecting parts which permit the salient novelty of the invention to accomplish its function, these words are only a convenient formula of the broadest equivalency of which the real invention permits."

(217 Fed. at 782-783).

The rule of *Davis Sewing Mach. Co.* v. *New Departure Mfg. Co.* has been cited with approval in many later cases. In some cases, as in *White Tool and Supply Co.* v. *Air Reduction Co.*, 48 Fed. (2d) 720, (C. C. A. 6); *Buono* v. *Yankee Maid Dress Corp.*, 77 Fed. (2d) 274, (C. C. A. 2); and *General Tire and Rubber Co.* v. *Fisk Rubber Corp.*, 104 Fed. (2d) 740, (C. C. A. 6), it has been cited to show that the use of the word "means" in a combination claim to define *other than the exact point of novelty* does not render the claim functional or invalid. In other cases, as in *Heidbrink* v. *Hardessen Co.*, 25 Fed. (2d) 8, (C. C. A. 7); *In re Tucker*, 46 Fed. (2d) 214, (C. C. P. A.); *In re Ferguson*, 83 Fed. (2d) 693 (C. C. P. A.); and *In re Spitzglass*, 96 Fed. (2d) 1002 (C. C. P. A.); it has been cited to show that the word "means" renders a claim functional

where it is directed to the novel element. In still other cases, such as *Hollingshead Co.* v. *Bassick Mfg. Co.*, 73 Fed. (2d) 543 (C. C. A. 6); *Firestone Tire and Rubber Co.* v. *United States Rubber Co.*, 79 Fed. (2d) 948 (C. C. A. 6) (Cert. denied 298 U. S. 679), it has been cited in support of a holding of non-infringement, the word "means" in combination claims being held to cover only the actual means described in the specification.

The soundness of the rule of the *Davis Sewing Machine* case has never been questioned. *Walker on Patents* (Deller's Ed.) Vol. 2, page 790, cites no other case under the heading, "Use of 'means' or 'mechanism,' etc., in claims," the author stating:

> "The interpretation to be given to such words as 'means,' 'mechanism,' etc., when used in claims, was fully discussed in *Davis Sewing Mach. Co.* v. *New Departure Mfg. Co.*, 217 Fed. 775, 782-784, C. C. A. 6 (1914), by Judge Denison. Because of the comprehensive nature of the discussion, the opinion is quoted in full:"

In *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, this Court cited the *Davis Sewing Machine* case in support of a ruling condemning the use of conveniently functional language at the exact point of novelty in a claim. This Court, speaking through Mr. Justice Reed, said:

> "The claim uses indeterminate adjectives which describe the functions of the grains to the exclusion of any structural definition, and thus falls within the condemnation of the doctrine that a patentee may not broaden his product claims by describing the product

in terms of function. (*Holland Furniture Co.* v. *Perkins Glue Co.*, 277 U. S. 245, 256-258, 72 L. Ed. 868, 872, 873, 48 S. Ct. 474, and cases cited). Claim 25 vividly illustrates the vice of a description in terms of function. 'As a description of the invention it is insufficient and if allowed would extend the monopoly beyond the invention.' (277 U. S. at 258). The Court of Appeals for the Ninth Circuit relied on the fact that the description in the claims is not 'wholly' functional. 80 Fed. (2d) 958, 963. But the vice of a functional claim exists not only when a claim is 'wholly' functional, if that is ever true, but also when the inventor is painstaking when he recites what has already been seen, and then uses conveniently functional language at the exact point of novelty. [See *Gynex Corp.* v. *Dilex Institute*, (C. C. A. 2d), 85 Fed. (2d) 103, 105; *Davis Sewing Mach. Co.* v. *New Departure Co.*, (C. C. A. 6th), 217 Fed. 775, at 782]."

—304 U. S. at 371, 82 L. Ed. at 1406-1407.

Claim 1 (R. 596) of patent 2,156,519 here in suit defines the part found below to constitute invention as "means associated with said pressure responsive device for tuning said receiving means to the frequency of echoes from the tubing collars." Everything in the claim except the tuning means is admittedly old. The particularity with which the other elements are defined is not important. When the exact point of novelty is reached only the function is recited. The claim in effect says merely: I claim means for tuning the receiver of a known echo depth measuring system to the frequency of echoes from the tubing collars.

Likewise, claim 13 (R. 597) of patent 2,156,519 defines the novel element only as "means associated with said re-

ceiving and registering means to accent the registration of tubing coupling echoes." No structure whatever is recited —only the function of some undefined means. Likewise, claim 14 (R. 598) defines the novel element only as "interference eliminating means;" claim 15 (R. 598) defines it as "resonance means associated with said receiving and registering means to produce therein a natural acoustical period of oscillation;" and claim 17 (R. 598) defines it as "means having a natural frequency of oscillation so related to the frequency of the echoes from said tubing couplings as to accent the registration of said echoes."

No one reading these claims can tell what this "means" is. This "means" includes everything that can perform the function. Such claims fall squarely within the class of those condemned by this Court in the *General Electric Co.* v. *Wabash Appliance Corp.* case.

The indefiniteness of these claims is not cured by the specification. In *General Electric Co.* v. *Wabash Appliance Corp.*, the Court said further:

> "The product claims here involved cannot be validated by reference to the specification. Assuming that in a proper case a claim may be upheld by reference to the descriptive part of the specification in order to give definite content to elements stated in the claim in broad or functional terms, the specification of the Pacz patent does not attempt in any way to describe the filament, except by mention of its coarse-grained quality."
>
> —304 U. S. at 373, 82 L. Ed. at 1407.

In the same way, in the case at bar, the specification of patent 2,156,519 throws no light on the functional language of the claims. The following terms are not used in the specification: "means to accent," "interference eliminating means," "resonance means," "natural acoustical period of oscillation" or "natural frequency of oscillation."

In *General Electric Co. v. Wabash Appliance Corp.*, the Court said further:

> "The inventor must 'inform the public during the life of the patent of the limits of the monopoly asserted, so that it may be known which features may be safely used or manufactured without a license and which may not'."
>
> —304 U. S. at 369, 82 L. Ed. at 1405.

No one having only patent 2,156,519 before him is apprised that these claims cover an electrical filter in the Lehr and Wyatt electrical system. No electric recorder with or without a filter is either described or shown. An entirely different application for patent (Exhibit L, R. 953) was prosecuted by Walker on the electrical recorder. The all-inclusive, purely functional clauses on the only novel element in the claims in suit do not "particularly point out" the improvement, and the specification does not describe the improvement in "full, clear, concise and exact terms," as required by R. S. Sec. 4888, if the improvement consists in putting an electrical filter in the prior Lehr and Wyatt system.

The language of *Burr* v. *Duryee*, 68 U. S. 531, 17 L. Ed. 650, 657, 658, is applicable.

"A machine is a concrete thing, consisting of parts, or of certain devices and combination of devices. The principle of a machine is properly defined to be 'its mode of operation,' or that peculiar combination of devices which distinguishes it from other machines. A machine is not a principle or an idea. The use of ill defined abstract phraseology is the frequent source of error. It requires no great ingenuity to mystify a subject by the use of abstract terms of indefinite or equivocal meaning. Because the law requires a patentee to explain the mode of operation of his peculiar machine, which distinguishes it from others, it does not authorize a patent for a 'mode of operation as exhibited in a machine.' * * *

"No one who reads the two specifications, or inspects the two machines, can aver that they contain the same combination of mechanical devices, or substantially the same, to produce the desired effect. Not one of the devices or its equivalent, used in the one is to be found in the other, nor is its mode of operation the same. The argument used to show infringement assumes that every combination of devices in a machine which is used to produce the same effect, is necessarily an equivalent for any other combination used for the same purpose. This is a flagrant abuse of the term 'equivalent.' * * * In the case of *McCormick* v. *Talcott*, 61 U. S. 402, 15 L. Ed. 930, 931, we have said: 'If the invention claimed be itself but an improvement on a known machine by a mere change of form or combination of parts, the patentee cannot treat another as an infringer who has improved the original

machine by use of a different form, or combinations performing the same functions. The inventor of the first improvement cannot invoke the doctrine of equivalents to suppress all other improvements which are not colorable invasions of the first.'"

The claims in suit are not infringed.

To establish infringement, it must be shown that the accused device is the same as that of the patent in suit or the equivalent. *American Steel & Wire Co.* v. *Denning Wire & F. Co.*, 176 Fed. 564, 565, affirmed 194 Fed. 117, C. C. A. 8; *Union Water-Meter Co.* v. *Desper*, 101 U. S. 332, 25 L. Ed. 1024.

To be the equivalent, *three requirements must be met.* There must be (1) substantially the same means, (2) substantially the same operation and (3) substantially the same result. *Bates* v. *Coe*, 98 U. S. 31, 25 L. Ed. 68, 72; *Westinghouse* v. *Boyden Power Brake Co.*, 170 U. S. 537, 569, 42 L. Ed. 1136, 1148.

In the present case:

1. There is not the same means. For example, a hot-wire microphone is not the same as the diaphragm of the patent (R. 341, 342). One is electrical; the other is mechanical. One does not respond to pressure pulses; the other does (R. 346, 358, 361). There is no interchangeability (R. 347). Interchangeability is an important test of identity of means. *Miller* v. *Eagle Mfg. Co.*, 151 U. S. 186, 208, 38 L. Ed. 121, 131.

2. There is not the same operation. For example, Petitioner's means for eliminating extraneous noises from being recorded does not operate in the same way as Walker's tuning pipe (R. 356). The tuning pipe amplifies the sound waves before they affect the receiver in any way (R. 355). An electrical filter does not affect the sound waves (R. 349, 456, 656), but changes the characteristics of an electrical amplifier (R. 357) by decreasing undesirable electrical currents picked up by the microphone (R. 363, 456). The filter does not amplify (R. 315, 318, 363). It is not "resonant" (R. 351, 352, 363), does not have a "natural acoustical period of oscillation" (R. 317, 457), and does not "accent" (R. 363). The Court is not even called upon to decide whether an electrical tuning device is the equivalent of a mechanical tuning device, because a filter is not a tuning device (R. 351, 352, 356, 357, 447, 458). The filter and the acoustical tuner of the patent are "entirely different in their mode of operation" (R. 356). The principle of law applies, that where the *mode of operation* of the accused machine is substantially different from that of the patent, infringement cannot exist. *Field* v. *DeComeau*, 116 U. S. 187, 29 L. Ed. 596; *Yale Lock Mfg. Co.* v. *Sargent*, 117 U. S. 373, 29 L. Ed. 950; *Universal Oil Products Co.* v. *Globe Oil & Ref. Co.*, 322 U. S. 471, 485, 88 L. Ed. 1399, 1407.

> "If the device of the respondent shows a substantially different mode of operation, even though the result of the operation of the machine remains the same, infringement is avoided." *Cimiotti Unhairing Co.* v. *American Fur Ref. Co.*, 198 U. S. 399, 414, 49 L. Ed. 1100, 1107.

3. There is not the same result. The records obtained are not the same. Petitioner's Echo-Meter is incapable of distinguishing pressure impulses from rarefaction impulses (R. 309, 358). The system of the patent in suit responds differently to these different impulses and makes distinguishable records of them (R. 309). (See analysis, *supra*, page 24).

In discussing the question of infringement, the Circuit Court of Appeals said (R. 1601, 1602):

> "Halliburton's argument of non-infringement is based primarily on the indisputable fact that it uses an electrical apparatus, whereas Walker's is mechanical. *Where different means are used to accomplish the same end or to perform the same function, the question of infringement depends upon the mode of operation as well as on the sameness of the result.* Cf. Walker on Patents (Deller's Ed.) Vol. 3, pp. 1745, 1750. While identity of result is of course not a sufficient test of infringement, nevertheless an infringing device, generally speaking, is one which 'does the same work in substantially the same way and accomplishes substantially the same result.'* Walker on

*The quotation is from the text of Walker on Patents, Deller's Ed., Vol. 3, page 1751. The full statement of the textbook is:

"But if the mode of operation is substantially the same, it does not follow that the charge of infringement must be affirmed. *Diamond Drill & Mach. Co.* v. *Kelly Bros.*, 120 Fed. 289 (1903); *E. Van Noorden Co.* v. *Cheney Co.*, 75 Fed. (2d) 298, 300 (C. C. A. 1) 1934). In that case the question must be decided by some additional criterion. To establish a claim of infringement, the facts must be subjected to several successive tests. If the case fails on either of those tests, no further inquiry need be made; but an infringement cannot be affirmed till all those tests have been applied and have been withstood.

"The first of these is that which relates to identity of mode of operation. It is therefore important to know wherein this requisite identity consists. It may be said in general that an infringing device is one which does the same work in substantially the same way and accomplishes substantially the same result."

Patents (Deller's Ed.) Vol. 3, pp. 1707, 1751. The question is whether Halliburton's device is substantially the equivalent of Walker's. * * *

"A detailed comparison of the *mode of operation, function, and result* achieved by the respective devices with which we are here concerned would expand this opinion to undue lengths."

As we read the Court's opinion, it holds that equivalency may exist between quite different devices if they have the same mode of operation, function and result. This has not heretofore been the law. The established rule is that there is no equivalency unless, in addition to these tests, there is "substantially the same or similar means." *Westinghouse* v. *Boyden Power Brake Co.*, 170 U. S. 537, 569, 42 L. Ed. 1136, 1148. The pages of Deller's Edition of Walker on Patents, relied upon by the Court, do not support its ruling. On page 1707 of Walker, it is stated:

"Sec. 469. Tests of Equivalency. Identity of Result. Similarity or identity of result is not a sufficient test to show infringement, where there was a variation in the means used (*Stebler* v. *Porterville Citrus Assn.*, 248 Fed. 927, C. C. A. 9; *Conrader et al.* v. *Judson Governor Co.*, 238 Fed. 349), but infringement is not avoided by the impairment of the functions of an element of a patented device. (*Sundh Electric Co.* v. *Gen. Electric Co.*, 198 Fed. 116; *Murray* v. *Detroit Wire Spring Co.*, 206 Fed. 465, C. C. A. 6.)"

On page 1745 of Walker it is stated:

"Sec. 495. Tests of Infringement of Machine or Manufacture. Comparative Results and Mode of Op-

eration. The respective results of a machine or manufacture covered by the claim of a patent, and of a machine or manufacture alleged to infringe that claim, do not furnish a criterion by which to decide the question of infringement. [*Westinghouse* v. *Boyden Power-Brake Co.*, 170 U. S. 537 (1898).]" (Other cases cited.)

On page 1746 of Walker it is stated:

"Those results may be identical, while the mode of operation and the means by which the result is secured are different. (*Electric Signal Co.* v. *Hall Signal Co.*, 114 U. S. 87, 29 L. Ed. 96.)" (Other cases cited.)

"Any person may accomplish the result performed by a patented thing without infringing the patent, if he uses means substantially different from those of the patent. [*O'Reilly* v. *Morse*, 15 Howard (56 U. S.) 62 (1853).]" (Other cases cited.)

"To hold the contrary of this rule would be to retard and not to promote the progress of the useful arts. [*Smith* v. *Downing*, 1 Fish. 64, Fed. Cas. No. 13,036 (1850).]"

On pages 1747, 1748, 1749 and 1750 of Walker, it is stated:

"A test of infringement, where similarity of function and result are involved, was discussed in *Union Paper Bag Machine Company* v. *Murphy*, 97 U. S. 120, 125, 24 L. Ed. 935, where the court said: 'Except where form is of the essence of the invention, it has but little weight in the decision of such an issue, the correct rule being that, in determining the question of infringement, the court or jury, as the case may be,

are not to judge about similarities or differences by the names of things, but are to look at the machines or their several devices or elements in the light of what they do, or what office or function they perform, and how they perform it, and to find that one thing is substantially the same as another, if it performs substantially the same function in substantially the same way to obtain the same result, always bearing in mind that devices in a patented machine are different in the sense of the patent law when they perform different functions or in a different way, or produce a substantially different result. * * * Authorities concur that the substantial equivalent of a thing, in the sense of the patent law, is the same as the thing itself; so that if two devices do the same work in substantially the same way, and accomplish substantially the same result, they are the same, even though they differ in name, form, or shape.'

"Similar language was used in *Electric Protection Co.* v. *American, Etc., Co.*, 184 Fed. 916, 923, C. C. A. 8 (1910): 'To sustain the charge of infringement the infringing device must be substantially identical with the one alleged to be infringed in (1) the result attained; (2) the means of attaining the result; and (3) the manner in which its different parts operate and co-operate to produce that result. If the devices are substantially different in either of these respects the charge of infringement is not sustained.' (Cases cited.)

"In *Boyden Power-Brake Co.* v. *Westinghouse*, 170 U. S. 537, 568, 569, 42 L. Ed. 1136, the court said: 'But even if it be conceded that the Boyden device corresponds with the letter of the Westinghouse claims, that does not settle conclusively the question of in-

fringement. We have repeatedly held that a charge of infringement is sometimes made out, though the letter of the claims be avoided. *Union Paper Bag Machine Co.* v. *Murphy*, 97 U. S. 120 (24:935); *Ives* v. *Hamilton*, 92 U. S. 431 (23: 496); *Morey* v. *Lockwood*, 75 U. S. 8 Wall. 230 (19:339); *Elizabeth* v. *American Nicholson Pavement Company*, 97 U. S. 137 (24:1005); *Sessions* v. *Romadka*, 145 U. S. 29 (36:609); *Hoyt* v. *Horne*, 145 U. S. 302 (36:713). The converse is equally true. The patentee may bring the defendant within the letter of his claims, but if the latter has so far changed the principle of the device that the claims of the patent literally construed, have ceased to represent his actual invention, he is as little subject to be adjudged an infringer as one who has violated the letter of a statute has to be convicted, when he has done nothing in conflict with its spirit and intent. "An infringement," says Mr. Justice Grier in *Burr* v. *Duryee*, 68 U. S. 1 Wall. 531, 572 (17:650, 658), "involves substantial identity, whether that identity be described by the terms, 'same principle,' same '*modus operandi*,' or any other. * * * The argument used to show infringement assumes that every combination of devices in a machine which is used to produce the same effect is necessarily an equivalent for any other combination used for the same purpose. This is a flagrant abuse of the term equivalent."

"'We have no desire to qualify the repeated expressions of this court to the effect that where the inventions is functional, and the defendant's device differs from that of the patentee only in form, or in a rearrangement of the same elements of a combination, he would be adjudged an infringer, even if, in certain particulars, his device be an improvement upon that of the patentee. But, after all, even if the patent for a machine be a pioneer, the alleged

infringer must have done something more than reach the same result. He must have reached it by substantially the same or similar means, or the rule that the function of a machine cannot be patented is of no practical value. To say that the patentee of a pioneer invention for a new mechanism is entitled to every mechanical device which produces the same result is to hold, in other language, that he is entitled to patent his function. Mere variations of form may be disregarded, but the substance of the invention must be there. As was said in *Burr* v. *Duryee*, 68 U. S. 1 Wall. 531, 573 (17:650, 659), an infringement "is a copy of the thing described in the specification of the patentee, either without variation, or with such variations as are consistent with its being in substance the same thing. If the invention of the patentee be a machine, it will be infringed by a machine which incorporates in its structure and operation the substance of the invention; that is, by an arrangement to mechanism which performs the same services or produces the same effect in the same way, or substantially the same way." "That two machines produce the same effect will not justify the assertion that they are substantially the same, or that the devices used by one are therefore mere equivalents for those of the other".' "

For the above reasons, we submit that there is no infringement. But even if it were true that the means, operation and result of Petitioner's device are sufficiently close to those of the patent in suit to invoke the doctrine of equivalents under normal circumstances, that doctrine is not applicable here because of the cancellation by Walker of a claim specific to Petitioner's accused device.

"It is a rule of patent construction consistently observed that a claim in a patent as allowed must be read and interpreted with reference to claims that have been cancelled or rejected and the claims allowed cannot by construction be read to cover what was thus eliminated from the patent. (Cases cited.) The patentee may not, by resort to the doctrine of equivalents, give to an allowed claim a scope which it might have had without the amendments, the cancellation of which amounts to a disclaimer. *Smith* v. *Magic City Kennel Club*, 282 U. S. 784, 790, 75 L. Ed. 707, 712, 51 S. Ct. 291; *Weber Electric Co.* v. *E. H. Freeman Electric Co., supra*, (256 U. S. 677, 678, 65 L. Ed. 1167, 1168, 41 S. Ct. 600); *I. T. S. Rubber Co.* v. *Essex Rubber Co., supra*, (272 U. S. 444, 71 L. Ed. 343, 47 S. Ct. 136). The injurious consequences to the public and to inventors and patent applicants if patentees were thus permitted to revive cancelled or rejected claims and restore them to their patents are manifest." (Case cited.)

—*Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, 220, 221, 85 L. Ed. 132, 137.

A patentee who has cancelled claims on particular subject matter has dedicated all rights which he might have had therein to the public. The patentee is "estopped to claim the benefit of his rejected claim on such a construction of his amended claim as would be equivalent thereto." *I. T. S. Rubber Co.* v. *Essex Rubber Co.*, 272 U. S. 429, 444, 71 L. Ed. 335, 343.

The cases of *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, 85 L. Ed. 132, and *Exhibit Supply Co.* v. *Ace Patents Corp.*, 315 U. S. 126, 86 L. Ed. 736, cited in our

Brief in Support of the Petition for the Writ of Certiorari are only two of many decisions of this Court which we think the Circuit Court of Appeals overlooked in failing to make any ruling whatever on the effect of the proceedings in the Patent Office. In addition to the case cited in *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, see

—*Sargent* v. *Hall Safe & Lock Co.*, 114 U. S. 63, 29 L. Ed. 67;

Shepard v. *Carrigan*, 116 U. S. 593, 29 L. Ed. 723;

Roemer v. *Peddie*, 132 U. S. 313, 33 L. Ed. 382;

Corbin Cabinet Lock Co. v. *Eagle Lock Co.*, 150 U. S. 38, 37 L. Ed. 989;

Hubbell v. *United States*, 179 U. S. 77, 83, 45 L. Ed. 95, 99;

Morgan Envelope Co. v. *Albany Perforated Wrapper Paper Co.*, 152 U. S. 425, 429, 38 L. Ed. 500, 502.

The facts in the present case are different from those in any of the above cited cases, but they are not sufficiently different, we submit, to warrant making an exception to the salutary and established doctrines dealing with the construction of claims of patents based on proceedings in the Patent Office.

The difference lies in the fact that Walker filed two applications for patent and the fact that the proceedings, upon which we rely chiefly to show the proper construction

of the claims in suit, took place in the application other than the one which matured into the patent in suit.

In their Brief (page 9) in Opposition to the Petition for the Writ of Certiorari, Respondents assert that Petitioner is seeking to distort the ruling of this Court in *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, to reach the absurd conclusion that a pioneer patentee dare not file applications for improvement for fear a rejection of claims in the improvement application would require the Courts to limit the claims of the pioneer patent.

Petitioner is seeking no such ruling. Respondents repeatedly assert that the rejection in their second application was upon the ground that the electrical apparatus thereof was the equivalent of the mechanical apparatus of the patent in suit. (See statements, pp. 8, 10 and 11 of Respondents' Brief in Opposition to the Petition for the Writ.) The statements of the Examiner as to equivalency were made long after patent 2,156,519 had issued, and are not the proceedings upon which Petitioner relies to support its position. Claim 15 upon which Petitioner bases its argument was rejected (R. 1002) on the prior patent to Lehr and Wyatt, and other prior art (R. 1000). It was never rejected on Walker patent 2,156,519.

This is not a case where an inventor has filed a second application on an improvement on his prior patented device. Walker conceived of the electrical system of the second application Exhibit L at about the same time that he conceived of the mechanical tuning device of the pat-

ent in suit.* The second application was filed Sept. 18, 1937 (R. 954), only eleven days after the filing of the first application. This is simply a case where two devices are thought of for accomplishing a desired result, and two applications are filed instead of one showing both embodiments.

While no case has been found where this Court has considered the effect of a patentee voluntarily dividing an invention and filing two applications, or the effect of proceedings in a co-pending application upon a patent, similar situations have arisen in the lower courts, and the established rules, as stated in 48 Corpus Juris 218 are:

> "Where it is in evidence from the record of the patent office that a certain construction was there contemplated, and that the patent would not otherwise have been granted, that construction will be followed, and no objection can be made to the same construction on the ground that it is narrow, and will render the patent practically useless. But an interpretation by the patent authorities extending claims beyond their proper import is not binding on the public. * * *
>
> "Where different applications by a patentee, and interference proceedings relating to the same subject matter are pending at the same time, all may be considered in determining the construction of the patent, as granted. * * *

*"Q. When did you first conceive of the idea of using a filter in an amplifier circuit in a recording system which has a microphone recorder as shown in figure 5 of the drawing of application serial No. 164,534, offered as defendant's Exhibit L?

"A. To the best of my knowledge that was about the time I started experimenting with acoustical tuning, which was during the early part of 1937." (Walker, R. 516, 517).

"Where an inventor divides up his invention so as to present certain elements in different patents, he is thereby limited to a more strict and narrow construction than might have been otherwise necessary."

In *North American Chemical Co.* v. *Dexter*, 252 Fed. 148 (D.C. E.D. Wisc.), there was a situation similar to that in the present case. Three patents to Thoma and one to Arnold, all assigned to the plaintiff, had been pending in the Patent Office at the same time. The Court investigated all the proceedings in the Patent Office, saying:

"It is my judgment that the court is not only permitted, but is required, to consider the plaintiff's claims, in view of the time and condition under which the four patents were brought out. They were practically concurrent and co-pending patents. Each one seeks to be contributory in a greater or less degree to the advance or change in the art which it is proposed to bring about. Whatever might have been the course to be pursued in interpreting or construing them, if they appear to be otherwise independent, the court is not at liberty, nor is it fair to the patentee, to ignore the express reference made in these several patent records to the pendency of the other patents and the general purposes sought to be accomplished by the four patents as a whole. If the problem concerned the interpretation of land or other property grants, each containing references to the provisions or the purposes of the other, the court would not hesitate to fully refer to all of them for the purpose of ascertaining the true intent and the construction to be placed upon each, as well as upon all." 252 Fed. at 160, 161.

In *Tampax, Inc.* v. *Personal Products Corporation*, 123 Fed. (2d) 722 (C. C. A. 2), the patentee, Hass, had cancelled claims from a first filed application. At the same time that he cancelled the claims he filed a second application with an amended specification and attempted to recapture what he had abandoned in the first application. The claims, which issued in the second application, were held limited by the doctrine of file-wrapper estoppel and hence not infringed. The Court said:

> "If Haas had secured the claim by the introduction of Figure Two and 'the second passage' into the first application, we cannot doubt that there would have been a 'file-wrapper estoppel.' *I. T. S. Rubber Co.* v. *Essex Rubber Co.*, 272 U. S. 429, 444, 47 S. Ct. 136, 71 L. Ed. 335; *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, 221, 61 S. Ct. 235, 85 L. Ed. 132. He would have failed to get a claim based upon such 'convolutions' as were inevitable by forcing a long strip into a short core; and in its place he would have secured a claim into which he introduced the element that the 'convolutions' must be regular zigzags. Obviously it made no difference that this limitation was incorporated into the claim only by references; and it also made no difference that the claim was itself transferred from the earlier application to another, co-pending with it. The doctrine of 'file-wrapper estoppel' depends upon the fact that, when an applicant has accepted the rejection of a broad claim he may not later assert that another claim, deliberately restricted to secure its allowance, is its equivalent; and that argument is as cogent when the claim is transplanted into a new application as when it is amended in the original." 123 Fed. (2d) at 723.

The facts in the *Tampax* case are, of course, different from those in the case at bar, but the case illustrates the importance of considering all the proceedings in the Patent Office relevant to the issuance of claims. If only the file wrapper of the patent in suit had been considered, no estoppel could have been shown.

In *Dodge Needle Co. v. Jones*, 159 Fed. 715 (C. C. A. 3), where the facts were similar to those in the *Tampax* case, the Court said:

> "* * * the admissions and statements of the applicant in the former case are not irrelevant to the issues now under consideration, and we are not to be asked to close our eyes to evidential facts upon a ground so slight as the one suggested.
>
> * * * * * * * * *
>
> "Whatever view we take as to the question, whether or not the application of August, 1901, was a continuation of the original application of November, 1899, it seems clear that, after the withdrawal of claims 4 and 5 of the new application, the invention covered thereby was abandoned, and needles with headed pins, as described therein, became public property, and cannot now be monopolized by the appellants." 159 Fed. at 722, 725.

In *Lewis Blind-Stitch Mach. Co. v. Arbetter Felling Machine Co.*, 208 Fed. 992, D.C. N.D. Illinois E.D. (Affirmed 219 Fed. 557) the facts were quite similar to those in the case at bar. Soon after Lewis filed the application which matured into the patent in suit, he filed another application called the "seam-application." (See 208 Fed.

1000). Both parties sought to construe the patent in suit by reference to the co-pending application. Judge Sanborn said:

> "Ordinarily a patent is to be construed by its own contents, its file wrapper, and a consideration of what there was left previously undiscovered in the particular art. The patent is the measure of the grant; other applications not usually being material to its construction. But the rule of construction adopted respecting several deeds or contracts between the same parties, made about the same time, relating to the same subject-matter, and as parts of the same transactions, undoubtedly applies to patents and patent applications. All may be resorted to on an inquiry as to the meaning of any one. The seam-applications, interference, and Lewis' patent application, related to the same subject-matter, and were all pending during substantially the same period. Therefore all may be looked into to determine the proper construction of the Lewis patent." 208 Fed. at 1001.

All of the proceedings in the Patent Office are conducted in the name of the Commissioner. While the mass of business is so great that the Commissioner does not review all the actions of the Examiners, there appears to be no sound reason for excluding consideration of any proceeding conducted in his name, if it is relevant.

In the present case, it must be presumed that the Examiner of Division 5, who handled the application which matured into the patent in suit, regarded the claims as limited to an acoustical device. That is all that is disclosed in the patent. The Examiner cited no art on elec-

trical filters or electrical tuning. Had he regarded such systems as within the scope of the claims, it would have been his duty to consult with the Examiner in Division 42. The result would have been a citation of art on electrical tuning and the rejection of the claims on the basis that no invention was involved in incorporating a filter in the Lehr and Wyatt electrical recording system, just as the Examiner in Division 42 rejected (R. 1002) claim 15 specific to the electrical system on that basis when the question was presented to him in the co-pending application Exhibit L (R. 953).

In the very file wrapper of the patent here in suit we have a situation the same as that in the *Schriber-Schroth Co.* v. *Cleveland Trust Co.* case. Walker cancelled claims (20 and 27—see analysis *supra*, pages 42-43), and inserted the more limited claims here in suit, when rejected on the prior art. Extensive arguments and representations were made to the Patent Office that the revised claims containing the new phrases "pressure responsive device," "means for tuning," "means to accent," "interference eliminating means," "resonance means," "natural acoustical period of oscillation," etc., limited the claims to the structure shown in the drawing and described in the specification. It was argued repeatedly that the phrase "means for creating a pressure impulse" distinguished from the gun of the Batcheller patent.

We submit that the Circuit Court of Appeals erred in ignoring the proceedings in the Patent Office, in both the application (Exhibit T) which matured into the patent in

suit, and the co-pending application (Exhibit L). We submit that each of these applications shows clearly that Petitioner's device does not infringe the claims in suit, because it uses a gun instead of a pressure impulse chamber, because it uses a hot wire microphone instead of a pressure responsive diaphragm, and because it uses ordinary electrical equipment to amplify the desired signals instead of an acoustical resonator. Respondents sought, but the Patent Office refused to grant, a patent on such a device, and the patent in suit should not be construed to cover it.

Conclusion

Respondents seek a monopoly on apparatus entirely different than that disclosed or intended to be covered by the patent grant. In consideration for disclosure of a pressure impulse chamber and a mechanical system for recording pressure pulses made with it, they seek, by broad, indefinite and functional claims, to prevent Petitioner from using a gun with an old and well-known electrical system adapted to record echoes. They ask the Court to ignore such limitations as were imposed in the claims during the prosecution of the application in the Patent Office and to ignore negotiations in the co-pending application seeking claims specific to an electrical recording system like that used by Petitioner.

The decisions of this Court in *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, and *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, preclude the attainment of such a result.

The claims are not drawn in accordance with the requirements of R. S. Sec. 4888 and should be declared invalid because they are functional and broader than the invention. If valid, they should be held not infringed by apparatus differing from that disclosed in the patent in means, operation and result. The proceedings in the Patent Office show that a device like Petitioner's was expressly excluded from the patent grant.

The decision of the Circuit Court of Appeals should be reversed.

Respectfully submitted,

EARL BABCOCK,
Duncan, Oklahoma,
Attorney for Petitioner.

November, 1945

FILE COPY

In the

Supreme Court of the United States

(OCTOBER TERM, 1946)

No. 24

HALLIBURTON OIL WELL CEMENTING COMPANY,
a Delaware corporation,
Petitioner,

VERSUS

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM
doing business as Depthograph Company,
a copartnership,
Respondents.

BRIEF FOR HALLIBURTON OIL WELL CEMENTING COMPANY, PETITIONER, ON REARGUMENT BEFORE A FULL BENCH

EARL BABCOCK,
Duncan, Oklahoma;
HARRY C. ROBB,
Woodward Building,
Washington 5, D. C.,
Attorneys for Petitioner.

August, 1946.

CUTTERBACK TYPESETTING CO., 13 S. WALKER, OKLAHOMA CITY, 4, OKLA.

TOPICAL INDEX

	PAGE
Statement of the Case	1
Opinions Below	2
Jurisdiction	2
Specification of Errors	3
Questions Presented	4
History of the Development of the Art	5
Patent in Suit is for an "improvement"	5
In 1898, Batcheller patent disclosed use of echoes to locate obstructions	6
In 1927, Union Oil Co. used gun and electrical recorder to locate obstructions in oil wells	6
In 1933, Lehr and Wyatt of the Shell Oil Co. used a device creating a pressure impulse for locating obstructions in wells	6
The disclosure of the Lehr and Wyatt patent	9
The Novelty in the Patent in Suit	10
The addition of an acoustical tuned resonator to the Lehr and Wyatt system	13
An acoustical tuned resonator was old in an analogous art	14
The Accused Device	17
The "Echo-Meter" uses a gun instead of a pressure impulse chamber and an electrical recorder particularly designed to respond to gun shots	18
The hot-wire microphone used was invented by Major Tucker to record gun shots in 1918	21

INDEX—(Continued)

PAGE

Details of Echo-Meter 22

The Echo-Meter has an electrical filter in the amplifier circuit 22

The holding of infringement is based upon the use of a filter 25

Filters and tuning devices were well known in the art 25

Walker, in his early experiments, purchased "on the market" an amplifier with a built-in filter 26

Analysis of the Claims in Suit 30

The only novel element in the claims—the acoustical tuned resonator—is defined only as "means" for accomplishing the desired function 33

An electrical filter is not a tuning device and has nothing in common with a tuned pipe..... 35

Extrinsic evidence as to equivalency between a tuned pipe and an electrical filter should not be considered 36

The patent in suit itself precludes broad interpretation 37

Proceedings in the Patent Office 38

Two applications filed contemporaneously by Walker, one on a mechanical recorder with an acustical resonator, and the other on an electrical recorder with an electrical filter 39

In the electrical application, the Examiner rejected a claim to the use of an electrical filter as involving no invention over the prior Lehr and Wyatt patent and Walker cancelled the claim 41

INDEX—(Continued)

PAGE

In the mechanical application, which matured into the patent in suit, several material limitations were introduced to avoid rejections on the prior art 42

The proceedings show that it was not the intention of the Patent Office to grant claims in the mechanical application covering a device using a gun and an electrical recorder 42

Summary of Argument 46

The Claims in Suit are Invalid 46

The Claims in Suit are not Infringed 46

Conclusion 46

Argument 47

The Claims in Suit are Invalid 47

The statutes require a patentee to describe his invention accurately and claim it particularly 47

The requirement applies to combination claims as well as to any other claims 49

The Claims in Suit are to an old combination ... 55

The word "means" followed by a recital of function is too indefinite to comply with the statute where it is used to define the only novel element in a claim 56

The rule of Continental Paper Bag Co. v. Eastern Paper Bag Co., 210 U. S. 405, does not apply here, because in that case the novel elements were described with some particularity 58

INDEX—(Continued)

PAGE

In General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, the use of indefinite and functional language at the exact point of novelty in a claim was condemned 62

The Claims in Suit are not Infringed 68

For an accused device to be the equivalent of that of a patent, there must be substantial identity in (1) the result obtained; (2) the means of attaining the result and, (3) the manner in which the parts operate or co-operate 69

In the present case not one of these requirements is met 69

Tests of Equivalency 73

In Schriber-Schroth Co. v. Cleveland Trust Co., 311 U. S. 211, it was held that the doctrine of equivalents cannot be used to expand allowed claims to cover subject matter of cancelled claims 76

The rejection and cancellation of claim 15 in Walker's co-pending application, Exhibit L, prevents him from resorting to the doctrine of equivalents in the patent in suit to cover what he there abandoned 78

The rule is that where different applications relating to the same subject matter are pending, all may be considered in construing allowed claims 79

The file wrapper of the patent in suit precludes such broad interpretation as is necessary to cover Petitioner's Echo-Meter 84

Conclusion 85

INDEX—(Continued)

PAGE

AUTHORITIES

Allen Bradley Co. v. Erie Resistor Co., 104 Fed. (2d) 150 (C. C. A. 3) 51
Altoona Pub. Theatres v. Am. Tri-Ergon Corp., 294 U. S. 477, 79 L. Ed. 1005 17

Buono v. Yankee Maid Dress Corp., 77 Fed. (2d) 274 (C. C. A. 2) 61
Burr v. Duryee, 68 U. S. 531, 17 L. Ed. 650 ..... 18, 67

Century Electric Co. v. Westinghouse Elec. & Mfg. Co., 191 Fed. 350 (C. C. A. 8) 69
Cimiotti Unhairing Co. v. American Fur Ref. Co., 198 U. S. 399, 49 L. Ed. 1100 70
Cohen, In re, 133 Fed. (2d) 924, C. C. P. A.) 53
Continental Paper Bag Co. v. Eastern Paper Bag Co., 210 U. S. 405, 52 L. Ed. 1122 ..... 58, 59
Corning et al. v. Burdin, 56 U. S. 252, 14 L. Ed. 683 ..38, 49

Daniels v. Coe, 116 Fed. (2d) 941, (Ct. of App. D. C.) 77, 78
Davis Sewing Machine Co. v. New Departure Mfg. Co., 217 Fed. 775 (C. C. A. 6) 56, 57, 59, 62
Dodge Needle Co. v. Jones, 159 Fed. 715 (C. C. A. 3) .. 82
Dwight & Lloyd Sintering Co. v. Greenawalt, 27 Fed. (2d) 823, 832 (C. C. A. 2) 36

Electric Protection Co. v. American Bank Protection Co., 184 Fed. 916 (C. C. A. 8) 69
Electric R. R. Signal Co. v. Hall Railway Signal Co., 114 U. S. 87, 29 L. Ed. 96 ..... 38, 45
Exhibit Supply Co. v. Ace Patents Corp., 315 U. S. 126, 86 L. Ed. 736 3

Farmer's Cooperative Exchange v. Turnbow, 111 Fed. (2d) 728 (C. C. A. 9) 55
Ferguson, In re, 83 Fed. (2d) 693 (C. C. P. A.) 62
Field v. DeComeau, 116 U. S. 187, 29 L. Ed. 596 70

INDEX—(Continued)

PAGE

Firestone Tire and Rubber Co. v. United States Rubber Co., 79 Fed. (2d) 948 (C. C. A. 6) (Cert. denied 298 U. S. 679) 37, 62
Fuller v. Yentzer, 94 U. S. 288, 24 L. Ed. 103 38

General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, 82 L. Ed. 1402 ..... 3, 4, 46, 48, 50, 62, 65, 66, 85
General Tire and Rubber Co. v. Fisk Rubber Corp., 104 Fed. (2d) 740 (C. C. A. 6) 61
Goodwin v. Carloss Co., 116 Fed. (2d) 644, (C. C. A. 6) 61
Goodyear Dental Vulcanite Co. v. Davis, 102 U. S. 222, 26 L. Ed. 149 ..... 37, 45

Hazeltine Corp. v. Emerson Television Radio Inc., 129 Fed. (2d) 580 (C. C. A. 2) 53
Heidbrink v. Hardessen Co., 25 Fed. (2d) 8, (C. C. A. 7) 61
Hollingshead Co. v. Bassick Mfg. Co., 73 Fed. (2d) 543 (C. C. A. 6) 62
Horten et al., 151 Fed. (2d) 210, (C. C. P. A.) 51

Incandescent Lamp Patent, 159 U. S. 465, 40 L. Ed. 221 68
I. T. S. Rubber Co. v. Essex Rubber Co., 272 U. S. 429, 71 L. Ed. 335 77

John Bean Mfg. Co. v. Creagmile, 123 Fed. (2d) 182 (C. C. A. 9) 54

Koebel v. Coe, 105 Fed. (2d) 784 (Ct. App. D. C.) 38
Kool-Kooshin Mfg. Co. v. Mitchell, 102 Fed. (2d) 37, (C. C. A. 8) 51
Krause v. Coe, 120 Fed. (2d) 717, (Ct. of App. D. C.) 56

Lewis Blind-Stitch Mach. Co. v. Arbetter Felling Machine Co., 208 Fed. 992 (D. C. N. D. Illinois E. D.) 83

INDEX—(Continued)

PAGE

Lincoln Engineering Co. v. Stewart-Warner Corp., 303 U. S. 545, 82 L. Ed. 1008 56

Mackay Radio & Telegraph Co. v. Radio Corp. of America, 306 U. S. 86, 83 L. Ed. 506 3

Marconi Wireless Telegraph Co. v. United States, 320 U. S. 1, 87 L. Ed. 1731 25

Mead Johnson & Co. v. Hillman's Inc., 135 Fed. (2d) 955 (C. C. A. 7) 53

Merrill v. Yoemans, 94 U. S. 568, 24 L. Ed. 235 47

Miller v. Eagle Mfg. Co., 151 U. S. 186, 38 L. Ed. 121 .. 69

Minnesota Mining & Mfg. Co. v. Coe, 113 Fed. (2d) 512, (Ct.of App. D. C.) 53

Muncie Gear Works v. Outboard M. & Mfg. Co., 315 U. S. 759, 86 L. Ed. 1171 3

North American Chemical Co. v. Dexter, 252 Fed. 148, (D.C. E.D. Wisc.) 80

O. H. Jewell Filter Co. v. Jackson, 140 Fed. 340 (C. C. A. 8) 37

Permutit Co. v. Graver Corp., 284 U. S. 52, 76 L. Ed. 163 47

Rice v. Nash-Kelvinator Corp., 150 Fed. (2d) 457, (C. C. A. 6) 50

Schriber-Schroth Co. v. Cleveland Trust Co., 305 U. S. 47, 83 L. Ed. 34 68

Schriber-Schroth Co. v. Cleveland Trust Co., 311 U. S. 211, 85 L. Ed. 132 ..... 3, 4, 46, 77, 78, 85

Sinclair and Carroll Co., Inc. v. Interchemical Corp., 325 U. S. 327, 89 L. Ed. 1644 37

Spitzglass, In re, 96 Fed. (2d) 1002 (C. C. P. A.) 62

Summerhays v. Coe, 105 Fed. (2d) 73, (Ct. of App. D. C.) 79

Tampax, Inc. v. Personal Products Corporation, 123 Fed. (2d) 72? C. C. A. 2) 81, 82

INDEX—(Continued)

PAGE

Timken Detroit Axle Co. v. Cleveland Steel Products Corp., 148 Fed. (2d) 267, (C. C. A. 6) 53
Tucker, In re, 46 Fed. (2d) 214, (C. C. P. A.) 62
Tyden v. Ohio Table Co., 152 Fed. 183 (C. C. A. 6) 56

Union Water-Meter Co. v. Desper, 101 U. S. 332, 25 L. Ed. 1024 69
United Carbon Co. v. Binney & Smith Co., 317 U. S. 228, 87 L. Ed. 232 ..... 3, 48, 67
Universal Oil Products Co. v. Globe Oil & Ref. Co., 322 U. S. 471, 88 L. Ed. 1399 ..... 54, 70

Weber Electric Co. v. Freeman Electric Co., 256 U. S. 668, 65 L. Ed. 1162 33
Westinghouse v. Boyden Power Brake Co., 170 U. S. 537, 42 L. Ed. 1136 74
White v. Dunbar, 119 U. S. 47, 30 L. Ed. 303 33
White Tool and Supply Co. v. Air Reduction Co., 48 Fed. (2d) 720, (C. C. A. 6) 61

Yale Lock Mfg. Co. v. Sargent, 117 U. S. 373, 29 L. Ed. 950 70

STATUTES:
Revised Stautes, Sec. 4886 (U. S. C. title 35, sec. 31) .. 2, 49
Revised Statutes, Sec. 4888 (U. S. C. title 35, sec. 33) 4, 46, 47, 49, 67, 86

TEXTBOOKS:
Corpus Juris, Vol. 48, p. 218 79

Walker on Patents (Deller's Ed.)
Vol. 2, p. 790 62
Vol. 3, p. 1707 73
Vol. 3, p. 1745 73
Vol. 3, p. 1746 74

MISCELLANEOUS:
Webster's New International Dictionary (2d Ed. 1938) 35

In the

Supreme Court of the United States

(OCTOBER TERM, 1946)

No. 24

HALLIBURTON OIL WELL CEMENTING COMPANY,
a Delaware corporation,
Petitioner,

VERSUS

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM
doing business as Depthograph Company,
a copartnership,
Respondents.

BRIEF FOR HALLIBURTON OIL WELL CEMENTING COMPANY, PETITIONER, ON REARGUMENT BEFORE A FULL BENCH

STATEMENT OF THE CASE

This is a suit for patent infringement. Cranford P. Walker *et al.*, Respondents, brought suit against Halliburton Oil Well Cementing Company, Petitioner, in the United States District Court for the Southern District of California, Central Division, on three patents issued to Cranford P. Walker. Two of these patents were held invalid by the Circuit Court of Appeals for the Ninth Circuit. The third patent in suit, No. 2,156,519 (R. 587), was held valid and infringed. On October 15, 1945, certiorari was granted by this Court as to patent 2,156,519 only. On January 9,

1946, the cause was argued before this Court. On January 28, 1946, by an order *per curiam*, the judgment of the Ninth Circuit Court of Appeals was affirmed, this Court being equally divided. On February 25, 1946, a petition for rehearing brought by Petitioner was granted and the case was restored to the docket for reargument before a full bench.

Opinions Below

The District Court rendered no formal opinion, but the findings of fact and conclusions of law appear in the record (R. 28-32). The opinion of the Ninth Circuit Court of Appeals is reported at 146 Fed. (2d) 817 and is in the record (Vol. VI, R. 1594). The opinion *per curiam*, and the concurring opinion of Judge Denman, denying a petition for rehearing in the Circuit Court of Appeals on patent 2,156,519 are reported at 149 Fed. (2d) 896 and appear in the record (R. 1614).

Jurisdiction

The grounds for jurisdiction are:

1. The decree was rendered in a suit in equity brought under the Patent Statutes to determine the issues of validity and infringement of letters patent issued by virtue of Revised Statute No. 4886 (U. S. C., Title 35, Sec. 31).

2. The statute under which the jurisdiction of this Court is invoked is Sec. 240 (a) of the Judicial Code, 28 U. S. C. 347, as amended by the Act of February 13, 1925.

3. Cases which sustain the jurisdiction are:

—*United Carbon Co.* v. *Binney & Smith Co.*, 317 U. S. 228, 87 L. Ed. 232;

Schriber-Schroth Co. v. *Cleveland Trust Co.*, 311 U. S. 211, 217, 85 L. Ed. 132, 135;

Mackay Radio & Telegraph Co. v. *Radio Corp. of America*, 306 U. S. 86, 89, 83 L. Ed. 506, 508;

Exhibit Supply Co. v. *Ace Patents Corp.*, 315 U. S. 126, 128, 86 L. Ed. 736, 740;

Muncie Gear Works v. *Outboard M. & Mfg. Co.*, 315 U. S. 759, 766, 86 L. Ed. 1171, 1177.

Specification of Errors

The errors urged by Petitioner are that the Circuit Court of Appeals for the Ninth Circuit erred:

1. In affirming the decree of the District Court in holding Walker patent 2,156,519 to be valid and infringed by Petitioner;

2. In failing to reverse the decree of the District Court in holding the Walker patent 2,156,519 valid and infringed by Petitioner;

3. In holding Walker patent 2,156,519 to be valid;

4. In holding Walker patent 2,156,519 to have been infringed by Petitioner;

5. In failing to hold that the law established by the decision of this Court in *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, 82 L. Ed. 1402, was controlling and dispositive of the litigation;

6. In failing to hold that the law established by the decision of this Court in *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, 85 L. Ed. 132, was controlling and dispositive of the litigation;

7. In holding that claims 1, 13, 14, 15 and 17 of Walker patent 2,156,519 define the alleged improvement thereof with sufficient distinctness and clarity to comply with R. S. Sec. 4888 requiring a patentee to "particularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery;"

8. In holding that claims 1, 13, 14, 15 and 17 of Walker patent 2,156,519 cover the use of electrical apparatus not shown or described in the patent, after the Patent Office had refused to grant Walker a claim specific to such electrical apparatus in a copending application for patent.

Questions Presented

The questions presented by the petition are:

Question 1. Is the doctrine of the case of *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, 82 L. Ed. 1402, condemning the use of indefinite and functional language at the exact point of novelty in a claim of a patent, applicable to a claim on a combination of elements, or should the doctrine be limited, as held (R. 1614, 1616) by the Ninth Circuit Court of Appeals, to a claim on a "single element" or "specific product"?

Question 2. Is the doctrine of the case of *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, 85 L.

Ed. 132, precluding the giving of a claim of a patent such scope as will include within its terms subject matter rejected and cancelled while the application for patent was pending, applicable to a situation where an inventor files two applications on different species of his invention, the rejection and cancellation taking place in one and the claim in suit issuing in the other?

History of the Development of the Art

Patent 2,156,519 (R. 587) is concerned with the location of the level of fluid or an obstruction in a well, such as an oil well. The apparatus disclosed includes a cylinder of gas under pressure adapted to be connected to the casing of the well. A quick-opening valve is provided so that the gas may enter the well rapidly and create a pressure wave in the annular space between the casing and tubing in the well. A system for recording on a chart the time when the wave is initiated and the time when echoes return from obstructions in the well, serves as means to enable calculations to be made as to the depth to the obstructions.

The District Court found that patent 2,156,519 was an "improvement" patent (R. 28). Indeed, patent 2,156,519 itself acknowledges (R. 591, Col. 2, *l.* 14) the prior Patent No. 2,047,974 to Lehr and Wyatt, and states (R. 591, Col. 2, *ll.* 18-20) that it is an object of Walker's' invention to improve upon the method disclosed in the Lehr and Wyatt patent.

Even prior to Lehr and Wyatt, it had been proposed to time echoes to measure distance in tubing. As early as 1898, in the patent to Batcheller No. 602,422 (R. 1065), it had been proposed to locate obstructions in this way. A gun K was fired into a tube J and the echo was detected and recorded by mechanism H (shown in detail in figure 4 of the patent) such as that commonly used in those days to make phonograph records.* In figure 5 (R. 1068) of the Batcheller patent, n^1 indicates the record made at the time the gun was fired and n^2 the record made on the return of the echo. The time required for the echo being proportional to the distance the sound traveled, the location of the obstruction could be calculated.

The Union Oil Company was the first to propose the use of this kind of apparatus for locating fluid levels in oil wells. In 1927 an apparatus for this purpose was built (R. 506). A gun was used to make a sound and a record of the time required for the echo to come back from the fluid in the well was made with ordinary electrical equipment consisting of a microphone, an amplifier and a motion picture camera recorder (R. 506-511).

Sometime prior to November, 1933, the Shell Oil Com-

---

*As shown in detail in figure 4 of the Batcheller patent (R. 1068):

"The sound-impluse-recording mechanism operates a light pivot-lever H, having at its end a stylus *h*. This lever, as shown, is pivoted to a frame H^2, supported on the standard E^2, the pivot being indicated at H^1, a light spring H^3 acting to press the lever H in one direction, as shown in Figs. 1 and 4, and an adjusting-screw H^8 being provided as an abutment to prevent the movement of the lever H against the spring beyond a definite point. The lever is actuated by a connection H^7, connected also to a diaphragm H^6, which is secured to a block H^4, hollowed out to form a chamber H^5, into which opens a passage h^4, or rather a tubular connection H^{11}, screwing into the passage h^4." (R. 1070).

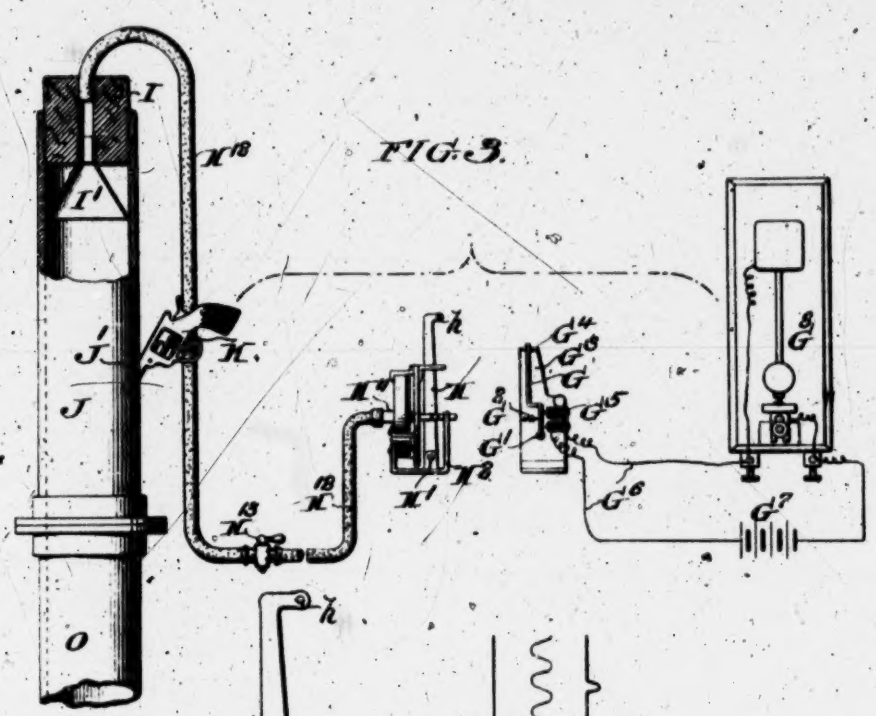
(No Model.) 2 Sheets—Sheet 2.

B. C. BATCHELLER.

APPARATUS FOR LOCATING OBSTRUCTIONS IN TUBES.

No. 602,422. Patented Apr. 19, 1898.

FIG. 3.


I
I'
J'
J
K
K'
K'
K'

pany decided to use echoes to determine fluid levels in wells (R. 245). Lehr and Wyatt were experienced oil men and employees of the Shell Oil Co. (R. 245, 250, 262). They had heard rumors about the work which had been done by the Union Oil Co. (R. 246, 247, 264). The Lehr & Wyatt patent 2,047,974 acknowledges (R. 1103, Col. 1, *ll.* 10-27) prior attempts to measure depths of wells with sound waves. Lehr and Wyatt experimented with a gun and other sound producing devices (R. 264, 265), but they decided to use a pressure chamber instead of a gun for creating a pressure impulse. Lehr testified that a .38 caliber gun did not have enough energy to produce satisfactory results (R. 265, 266) and his patent states that the "sound method" is more or less unreliable (R. 1103, Col. 1, *ll.* 41-42). A gun causes a "pressure impulse" as well as a sound (R. 336), but if gas is compressed in a cylinder and then liberated into the well through a quick-opening valve, the pressure impulse is much greater. "Compared with an impulse chamber, three pounds pressure * * * gave much more of a return than a .38 cartridge." (Lehr, R. 265, 266). The Lehr and Wyatt patent suggests that the pressure in the chamber be 100 pounds per square inch (R. 1104, Col. 1, *l.* 40). The pressure impulse chamber is shown at 4 in the drawing (R. 1102) of the Lehr and Wyatt patent. When the valve 6 is opened, gas is admitted into the annular space between the tubing 8 and the casing 14 of an oil well and creates a pressure impulse therein. Ths pressure impulse, traveling at the same speed as that of sound (R. 338), goes down the well and echoes back. By observing the elapsed time for this impulse to traverse

the space from the well head to an obstruction or liquid level in the well and return, the depth of the obstruction or liquid level can be determined.

The Lehr and Wyatt patent states (R. 1104, Col. 1, *ll.* 3, 4) that the elapsed time may be observed or indicated in any desired manner. As disclosed in Fig. 2. (R. 1102) one apparatus for making this observation is an ordinary microphone 15, provided with a suitable electrical amplifier 18 and a recorder 16. The recorder may be of a known type, in which a pen or pencil 21 runs on a recording drum 23 and is controlled by the circuit 17 from the microphone and amplifier. With such a device a record is made when the valve is opened to let the pressure impulse into the well and also when the echo returns from an obstruction in the well.

It is inherent in the Lehr and Wyatt device that if a partial obstruction in the well sends back an echo, that also will be recorded. Experiments conducted by experts in this art show that apparatus constructed in accordance with Figure 2 of the Lehr and Wyatt patent is operative to record a fluid level in a well and also to record the level of other obstructions or partial obstructions, such as a tubing catcher or collars on tubing in the well. See Exhibits F, G, H and I (R. 885-889) for actual recordings and see testimony thereon (R. 292, 293, 416-434).

The Novelty in the Patent in Suit

Thus the art was quite well developed by the time Walker entered the field. Walker was not a pioneer. As a

y 21, 1936. P. E. LEHR ET AL 2,047,974

METHOD AND APPARATUS FOR MEASURING WELL DEPTHS

Filed Nov. 1, 1933

Fig. 1

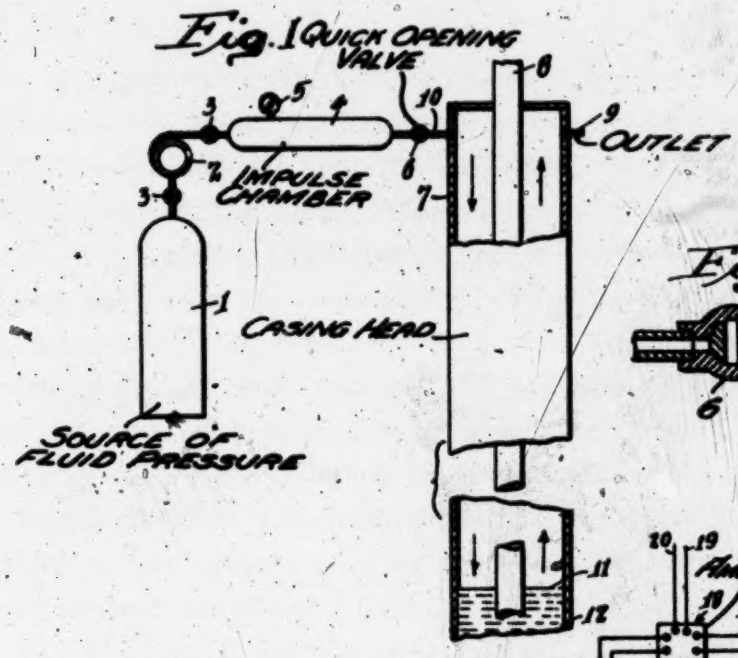


Fig. 4

Fig. 2

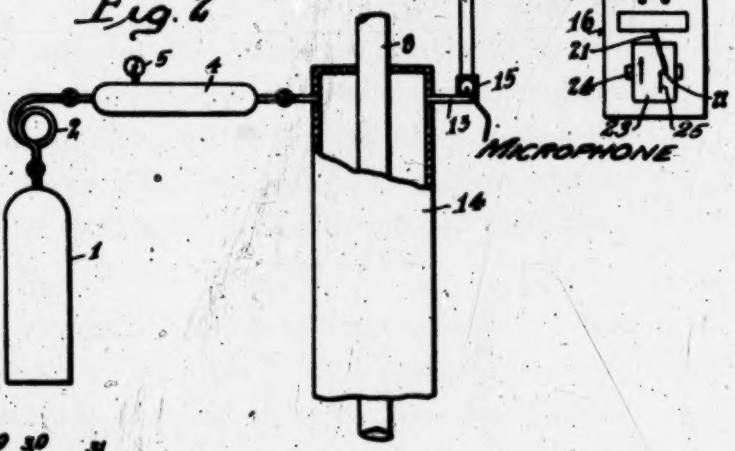
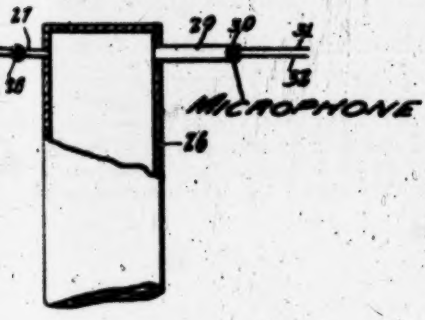


Fig. 3



Inventors

Harold S. Wyatt
Paul E. Lehr

By Lyon & Lyon

Attorneys

matter of fact, he became interested in this art as the result of a demonstration to him by Lehr of the pressure impulse method of locating fluid level on one of the Shell Oil Company wells at Ventura, California, in October, 1935 (R. 154, 155, 514, 515). Walker adopted Lehr's pressure chamber with a quick-opening valve for creating a pressure impulse in the well. Instead of Lehr's electrical recorder, he adopted a mechanical one using a diaphragm like that of the Batcheller patent 602,422 (R. 1068). Insofar as this case is concerned, admittedly there was no invention in making this change. Walker's improvement, found by the courts below to constitute invention, resides in the addition to this apparatus of an acoustical resonator to accent echoes from tubing collars.

In the drawing of the Walker patent in suit (R. 588), the pressure impulse chamber is shown at 12, and the quick-opening valve at 16. These are connected to the well casing 4 by the coupling 19. The pressure impulse and its echoes are conveyed to the recording system by the pipe 18. The recording system includes a diaphragm 23 and a mirror 26, so that by the light beam 37 the pulses are recorded on a photographic film 39.*

Walker's system differs from the recorders of the prior art in the use of a pipe 18 of a particular length. There being nothing electrical about his recording system, Walker could not use an electrical amplifier such as that

*The use of a light beam and photosensitive film was old. See the patent to Taylor (R. 1096). In the Taylor patent, movement of the mirror 11 is recorded on the film 2. Light from the lamp 12 is directed upon the mirror 11 and then through the optical system in the tube 5 to expose the film 2. (See specification R. 1097).

disclosed in the Lehr and Wyatt patent, to increase the intensity of returning signals, so he used an acoustical tuned resonator to amplify the echoes. The pipe 18, adjustable in length by the coupling 19, serves this purpose. The pipe 18 connects the housing for the pressure responsive diaphragm 23 to the well casing. The pipe can be "tuned" by adjusting its length to cause it to respond particularly to echoes from tubing collars. These echoes are then said to be "amplified," while echoes from other obstructions or partial obstructions are "damped out" (R. 595, Col. 1, *ll.* 48-71). The only novel element in the claims here in suit is the adjustable mechanical tuning pipe 18.* Both lower courts found the novelty in the patent to reside in the addition of this element to the Lehr and Wyatt system (R. 29, 1599, 1600). The District Court called it a "tuned acoustical resonator" (R. 29) and the Circuit Court of Appeals called it an "adjustable tuning pipe" (R. 1598).

While new in a device for recording echoes in wells, an adjustable pipe is not a novel means for causing a sound recorder to respond particularly to a certain frequency. In Fig. 17 of the patent to Tucker No. 1,451,356 (R, 1080), granted August 31, 1920, such a device is shown associated with a microphone connected to a system which may be recording.†

---

*On the attached drawing of the patent in suit, we have circled the reference numeral 18 for emphasis, since the alleged invention resides in the use of this adjustable pipe.

†The Tucker patent shows only an indicator such as a bell F or lamp H, but on page 4 of the patent (R. 1086 *ll.* 18-20) it is stated that "it may be understood that any other indicating or recording device may be used instead."

May 2, 1939. C. P. WALKER 2,156,519

MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Filed Sept. 7, 1937 2 Sheets-Sheet 1

FIG. 1.

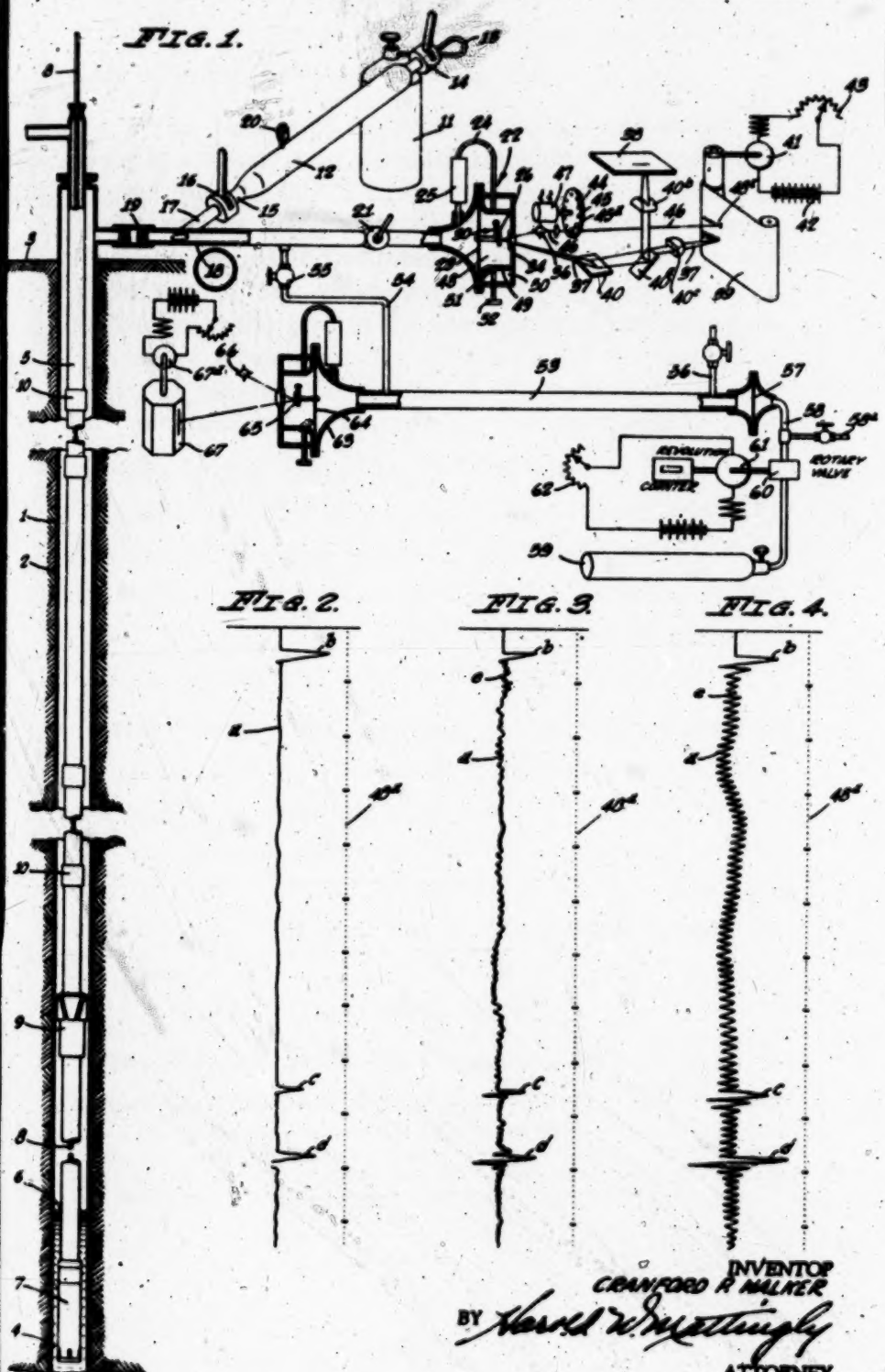


FIG. 2.

FIG. 3.

FIG. 4.

INVENTOR
CRAWFORD P. WALKER
BY Harold W. Mattingly
ATTORNEY.

A tuned acoustical resonator was not even new with Tucker. His patent states (R. 1085, Col. 1, *ll.* 47-58):

> "The tuning of each combined unit of sound detecting device and acoustic resonator to a particular pitch may be either fixed or adjustable; in either case the tuning being attained in a well known manner by the proper adjustment of the shape, length, and volume of the resonating chamber, or of the aperture near the grid of the thermic sound detecting device, or otherwise. Fig. 17 illustrates the method of tuning wherein the volume of the resonating chamber 1 is varied by a telescopic sliding movement."

Both of the lower courts have held, in effect, that invention is involved in making a better sound record by selecting the recording system of the Tucker patent, which has an acoustical resonator, for use in the recording system of the Lehr and Wyatt patent, which has an electrical amplifier but does not have an acoustical resonator.*

The invention has been held by the Circuit Court of Appeals to be of such a pioneer nature as to cover much more than this selection, however. It has been held to cover an electrical recording system not disclosed or even hinted at in the patent. Petitioner's device has been held to infringe even though it has no acoustical resonator.

The Accused Device

In 1936, the Union Oil Company asked Dr. John J. Jakosky to develop the device that company had first ex-

*In *Altoona Pub. Theatres* v. *Am. Tri-Ergon Corp.*, 294 U. S. 477, 486, 79 L. Ed. 1005, 1011, it was held that selection of elements from the prior art to make a better sound record did not involve invention.

perimented with in 1927 (R. 490, 491). The outcome was the apparatus known as the "Echo-Meter" (R. 491). Jakosky organized a company, International Geophysics, Inc., and for a time it provided the Echo-Meter service to the oil fields (R. 300). In May, 1940, the Petitioner, Halliburton Oil Well Cementing Company, purchased the business of International Geophysics, Inc., and rights under such patents as might issue on the Echo-Meter (R. 708).

In developing the Echo-Meter, Jakosky selected only devices known in the prior art.* He employed neither the Lehr and Wyatt system nor the Walker improvements thereon. He used a gun to create a sound, whereas Lehr and Wyatt and also Walker had used a pressure impulse chamber; and he used a microphone, electrical amplifier and recorder to record the shot and echoes, whereas Walker had used a diaphragm recorder. A Tucker microphone was selected as one particularly suitable for recording gun shots. It consists merely of a grid of fine wire heated electrically, the wire being of such nature that its resistance varies greatly with temperature (R. 288, 289). A puff of air through the grid in either direction cools it and changes the resistance in proportion to the velocity of the air

---

* Jakosky had the right to work out another system for locating fluid levels by the use of echoes.

"All others have an equal right to make improved machines, provided they do not embody the same or substantially the same devices or combination of devices, which constitute the peculiar characteristic of the previous invention. * * *

"But it has been argued, that though not a colorable *invasion* of the patentee's claim, it is an *evasion* of his patent, which is equally injurious. If so, it is *'damnum absque injuria.'* Every man has a right to make an improvement in a machine, and evade a previous patent, provided he does not invade the rights of the patentee." *Burr* v. *Duryee*, 68 U. S. 531, 17 L. Ed. 650, 658, 659.

W. S. TUCKER.
SOUND DETECTING DEVICE.
APPLICATION FILED JAN. 6, 1919.

,351,356.

Patented Aug. 31, 1920.
4 SHEETS—SHEET 2.

Fig.3.

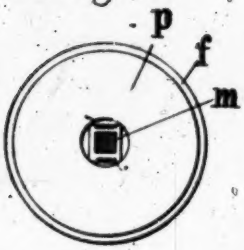


Fig.4.

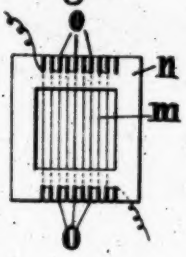
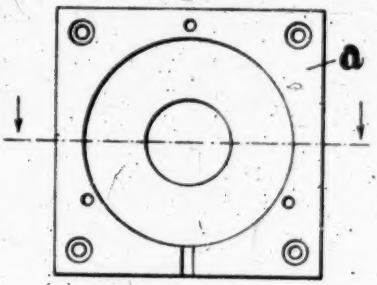


Fig.7.



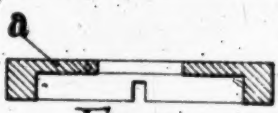


Fig.8.

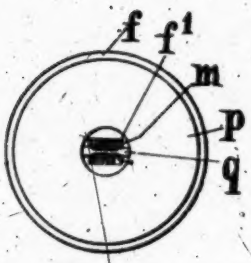


Fig.5.

Fig.6.

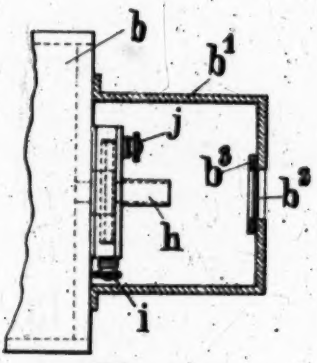


Fig.11.

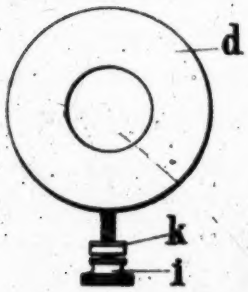


Fig.9.

Fig.10.

Inventor
W. S. Tucker
By L. R. Kerslake
Atty

(R. 289). By recording the resistance of the grid, a record of air movement is obtained (R. 289).

This microphone with an amplifier and a recorder was known (R. 392). It is described in U. S. Patent 1,351,356 to Tucker (R. 1077), granted August 31, 1920, for "Sound Detecting Device." Figure 4 of this prior patent shows the fine wire *m* wound on a frame *n*. Figure 3 shows this assembly mounted on a disc *f*, which has a central hole to allow a current of air to cool the wire *m*. This microphone was used as described by Tucker in a paper (R. 926), published January 5, 1923, before the Royal Society of Arts in London, entitled "The Hot Wire Microphone and Its Application to Problems of Sound." Tucker was a major in the British Army and designed this microphone in 1918 to locate enemy gun positions (R. 387, 388, 926).

The Echo-Meter consists essentially of a gun using a .38 caliber blank revolver cartridge or a 10-gauge blank shotgun shell (R. 288) mounted to discharge into a pipe connected to an oil well, and a Tucker hot-wire microphone to receive the gun shot and the echoes, the microphone being connected through a suitable amplifier, such as is commonly used in the radio art, to a recorder for making a record on a tape.* The technique and operation of the recording system are about the same as used by Tucker, except that Tucker used an acoustical resonator whereas the Echo-Meter does not. Some of Tucker's graphs

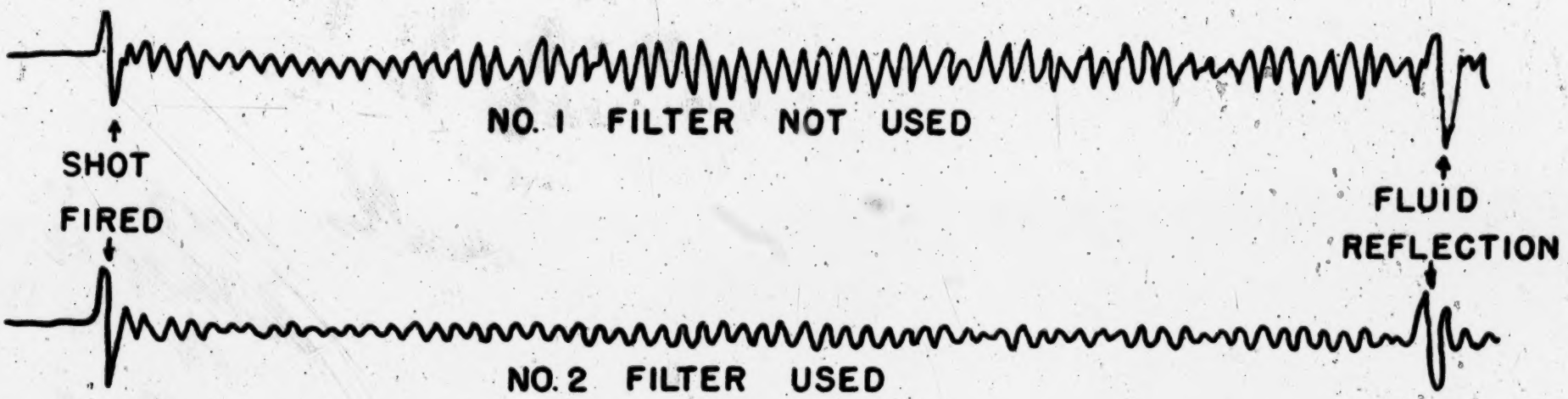
---

*The Echo-Meter is more fully described in the Field Manual (Ex. 11-C, R. 719). Exhibits 12-B, 12-C and 12-D (R. 755-757) are photographs of Petitioner's device which was brought into court. The methods used in operating it are described by Cornes (R. 273 *et seq.*) See also Answers to Interrogatories (Exhibits 10, 11 and 12, R. 646, *et seq.*), particularly the Answer to Interrogatory 14, R. 653, and Exhibit 10-A, R. 773.

appear in the Royal Society of Arts paper mentioned above (R. 927, 928, 930, 931). Commercial graphs made by Petitioner in the presence of Respondents (R. 280), are found in Exhibit D. (R. 884). A graph made in court (R. 278) with a piece of hose simulating an oil well is found in Exhibit C (R. 883).

The Echo-Meter is used to locate obstructions and fluid levels in wells (R. 624). The graphs obtained show echoes from tubing collars, tubing catchers or other obstructions (R. 282, 285, 311, 313, 649). If the distance between tubing collars is known, or if the position of the tubing catcher is known, a comparison of distances on the graph of echoes from these known obstructions with the echo from the fluid level affords a basis for computing the distance to the unknown fluid level (R. 286, 287).

In the amplifier circuit between the microphone and the recorder, the Echo-Meter is provided with an electrical filter which is used occasionally (R. 277, 314, 650, 651) to make the records more clear by excluding extraneous noise (R. 313-315, 650), but tubing collar echoes are recorded whether the filter is used or not. (Compare graph No. 1 at the top of Exhibit D, R. 884, where the filter was not used, with graph No. 2 of Exhibit D, where it was used and properly adjusted, and see testimony on Exhibit D, R. 282, 286, 287). When the electrical filter is not used, Respondents admit (R. 57, 58, 533-537) that Petitioner's Echo-Meter does not infringe patent 2,156,519, but Respondents contend (R. 534), and the lower courts found (R. 30, 31, 1603), that infringement exists when the electrical filter is used.



Tracings of Graphs 1 and 2 of Exhibit D, Made with Petitioner's Echo-Meter. (See R. 884 for Actual Exhibit D.)

Both of the above are retracings, for illustration in this brief, of commercial graphs obtained on an oil well in California with Petitioner's Echo-Meter on September 29, 1942. Respondent C. P. Walker was present when the graphs were made. A 10-gauge blank shotgun shell was used in making each, and one was made immediately after the other. In making graph No. 1, the filter was entirely disconnected. In making graph No. 2 the filter was used and properly adjusted. On each graph, the large waves show when the shots were fired and when the echoes from the fluid returned. The small waves about one-eighth of an inch long and of varying heights are recordings of echoes from collars on the tubing in the well. Tubing collar echoes were recorded whether the filter was used or not, but the filter eliminated extraneous noises. The recording system used to make graph No. 1 was the same as that of the prior Lehr *et al.* patent 2,047,974 (R. 1101). This graph is as much like figure 4 of patent 2,156,519 (see R. 588 or page 15 of this brief) as graph No. 2. The courts below have held that the apparatus used to make graph No. 2 infringes the Walker patent, while apparatus old in the prior art, used to make graph No. 1, does not anticipate the Walker patent.

Petitioner is free to make graphs like No. 1 of Exhibit D but has been held to infringe when a graph like No. 2 of exhibit D is made.

Petitioner is not charged with infringement because its Echo-Meter records echoes from tubing collars. The apparatus of the prior Lehr patent was inherently capable of recording echoes from such collars (R. 292, 293, 416-434) and it cannot be said that Walker invented apparatus for doing that. What is claimed is that Walker invented an acoustical resonator for tuning his receiver to accent tubing collar echoes, and that the electrical filter in Petitioner's Echo-Meter is the equivalent of an acoustical resonator.

A filter in an amplifying circuit is a common electrical expedient (R. 399, 651). It is an electrical device which controls the response of an amplifier (R. 350, 351) to eliminate extraneous noises. The filter contains resistance (R. 350) adjustable to reduce the gain in the amplifier of certain unwanted frequencies (R. 351, 363, 456). (See circuit diagram R. 734.)

Although the lower courts have held (R. 30, 1603) that a filter is the equivalent of an acoustical tuned resonator, there is no evidence whatever in the record supporting this holding. The uncontradicted expert testimony is that a filter is not even an electrical tuning device (R. 351, 356, 357). But electrical tuning devices are also old in the art. In fact, they are much older than filters (R. 352). In *Marconi Wireless Telegraph Co.* v. *United States*, 320 U. S. 1, 17, 30; 87 L. Ed. 1731, 1741, 1748, this Court found that electrical tuning devices were old in 1902. Filters were

not developed until about 1916, but they had become quite common long prior to Walker (R. 352).*

Filters had commonly been used in connection with amplifiers in electrical sound detecting systems. The patent to Williams No. 1,671,262 (R. 1089), granted May 29, 1928, shows a filter at 50 (R. 1090). The Williams patent states (R. 1092, *ll.* 21-25) that:

> "The present system while sensitive to very weak noises and signals is practically free from disturbances of the former, after the signals have been filtered and amplified."

Walker testified (R. 156) that in 1935 he decided to "take on the job of developing apparatus for the practice of the Lehr and Wyatt method."

He investigated "devices on the market, microphones, amplifiers and electrical recording devices" (R. 156, 157).

The amplifier he purchased had a filter built into it. Walker testified:

> A. "The amplifier that I used in making the records that have been submitted in evidence had a filter on it, a tone control, it is called in the ordinary

---

*Dr. Mackeown testified:

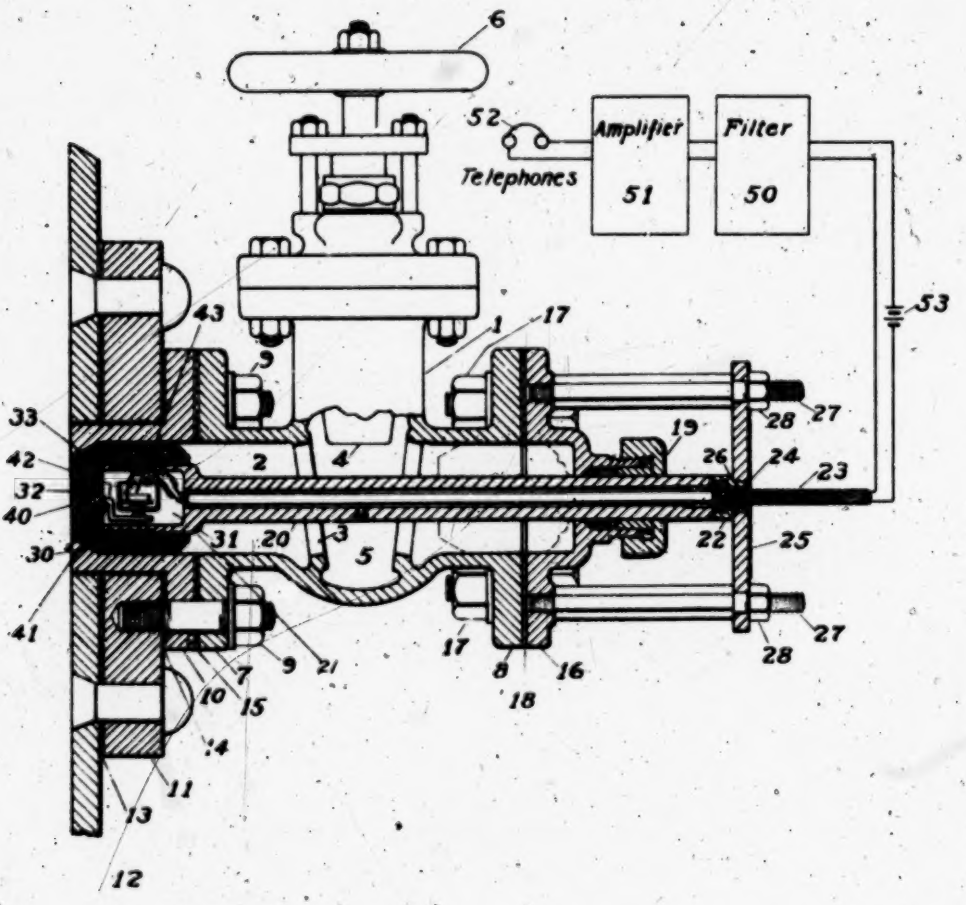
"Resonant circuits are extremely old. The theory was first worked out by Lord Kelvin about 1850. A filter circuit is relatively new, and was first worked out by Dr. Campbell of the Bell Telephone Laboratories in 1916. They have been used very extensively by the Bell Telephone Company and make possible a communication of ten or twenty telephone communications over two wires, so that each party can communicate, and not be heard by the rest. That is entirely done by a filter. They are entirely different from the resonant or tuned circuits, which cannot be operated that way." (R. 352).

May 29, 1928. 1,671,262

R. L. WILLIAMS.

SUBMARINE SOUND RECEPTION

Filed April 2, 1925



INVENTOR.
ROBERT L. WILLIAMS
BY Ezekiel Wolf
ATTORNEY

radio outfit. This was used, I understand it, for recording heart beats and had a filter on it which I used in my experiments, but it did not have much effect.

Q. What date are you referring to?

A. I am referring to experiments in the early part of November.

Q. What year?

A. 1935; November 13th to along towards the latter part of the month.

Q. That apparatus, was that an apparatus that had a microphone and an oscillograph in this recording circuit with the amplifier?

A. That is correct." (R. 516).

Anyone skilled in the art, in attempting to build apparatus in accordance with figure 2 of the Lehr and Wyatt patent would just as naturally have selected such an amplifier. The Lehr and Wyatt patent states that an amplifier may be used. It does not specify what kind of amplifier, but one skilled in the art would certainly know enough to purchase an amplifier "on the market," and one which had "a filter on it, a tone control, it is called in the ordinary radio outfit."

We submit that the Lehr and Wyatt patent *per se* teaches the use of a filter in the amplifier of an electrical recording system. If this patent alone is not sufficient to teach this, then the other prior art, such as the Williams patent, shows there is no invention in such use. If the claims of the Walker patent in suit are so broad as to cover

such use, they should be declared invalid. As will be shown presently, the Examiner in the Patent Office in charge of the art of Electric Signaling, refused to grant claims to Walker on exactly this combination.

Analysis of the Claims in Suit

Claims 1, 13, 14, 15 and 17 (R. 596-598) of patent 2,156,519 are in suit. These are copied here with the clauses directed to the allegedly novel element placed in italics:

"1. In an apparatus for determining the location of an obstruction in a well having therein a string of assembled tubing sections interconnected with each other by coupling collars, means communicating with said well for creating a pressure impulse in said well, echo receiving means including a pressure responsive device exposed to said well for receiving pressure impulses from the well and for measuring the lapse of time between the creation of the impulse and the arrival at said receiving means of the echo from said obstruction, and *means associated with said pressure responsive device for tuning said receiving means to the frequency of eehoes from the tubing collars of said tubing sections to clearly distinguish the echoes from said couplings from each other.*

* * * * * * * * * * *

"13. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from the couplings and other obstructions in said well, echo receiving and registering means coupled to said well to expose said re-

ceiving and registering means to pressure variations produced in said well by echoes from said obstructions, and *means associated with said receiving and registering means to accent the registration of tubing coupling echoes.*

"14. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from couplings and other obstructions in said well, pressure responsive echo receiving and registering means coupled to said well to expose said receiving and registering means to pressure variations in said well produced by echoes from said obstructions, and *interference eliminating means associated with said receiving and registering means for limiting the response of said receiving and registering means to the registration of echoes from actual obstructions in the well whereby the registered echoes of the tubing couplings may be readily distinguished from each other and from the echoes from other actual obstructions in the well.*

"15. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from the couplings and other obstructions in said well, pressure responsive echo receiving and registering means coupled to said well to expose said receiving and registering means to the pressure variations produced in said well by echoes from said obstructions, and *resonance means associated with said receiving and registering means to produce therein a natural acoustical period of oscilla-*

tion so related to the frequency of the echoes from the tubing couplings as to accent the registration of the tubing coupling echoes.

"17. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating therein a pressure impulse to produce echoes of said impulse from the couplings and other obstructions in said well, *pressure responsive echo receiving and registering means having a natural frequency of oscillation so related to the frequency of the echoes from said tubing couplings as to accent the registration of said echoes,* and means interconnecting said receiving and registering means to said well to expose said receiving and registering means to pressure variations in said well."

These claims use different language, but all are similar in construction, so only claim 1 will be analyzed specifically. In the introductory part, this claim calls for apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein interconnected with each other by coupling collars. The Lehr and Wyatt patent (R. 1101) shows an oil well with tubing 8 therein. The Lehr and Wyatt device was used in wells having tubing therein and the tubing had collars (R. 271). Therefore, there is no novelty defined in this part of the claim. The claim then calls for "means for creating a pressure impulse in the well." This is the same device as that of the Lehr and Wyatt patent—a pres-

sure impulse chamber and valve.* The claim further calls for "echo receiving means including a pressure responsive devise exposed to said well for receiving pressure impulses from the well." The pressure responsive device is the diaphragm 23 and associated parts. There is no diaphragm in the Lehr and Wyatt patent, but there is no invention in its use instead of a microphone, because Batcheller (R. 1065) shows a diaphragm.†

The final clause of the claim defines the only element alleged to be novel, and the only element found by the courts below to be novel (R. 29, 1599, 1600). It calls for "means associated with said pressure responsive device for tuning said receiving means to the frequency of echoes from the tubing collars." *The entire novelty of the alleged invention is defined simply as "means" for accomplishing the desired function.* What this "means" is, how it operates, or how it co-operates with the other parts of the apparatus is not defined. Walker has added a resonance pipe to the Lehr and Wyatt system, but he seeks a monopoly on all means for tuning a receiver in such system.

---

*The patent seems to exclude the use of a gun by calling for an arrangement by which pressure pulses can be adjusted and by making a distinction between sound methods and pressure impulse methods. See testimony of Dr. Mackeown (R. 470-471). In setting forth the objects of the invention (R. 591), a careful distinction is made in the patent between the use of low energy sound waves and high intensity impulses produced by the Lehr and Wyatt pressure chamber. Respondents should not now be permitted to turn around and say that the use of sound waves as taught by Batcheller is an infringement of the claims. *Weber Electric Co.* v. *Freeman Electric Co.*, 256 U. S. 668, 65 L. Ed. 1162. Such expansion of claims is "an evasion of the law." *White* v. *Dunbar*, 119 U. S. 47, 30 L. Ed. 303, 305.

†If the claim is interpreted to limit this phrase to definition of a diaphragm, together with the particular mounting for the diaphragm as we think was intended by Walker when it was drawn, then clearly there is no infringement, for Petitioner, like Lehr and Wyatt, uses a microphone.

The other claims in suit use the same kind of language to define the alleged novelty. The clause of claim 13 (R. 597) which is supposed to define invention over the Lehr and Wyatt patent reads, "means associated with said receiving and registering means to accent the registration of tubing coupling echoes." The word "accent" does not even appear in the specification. Claim 14 (R. 598) defines the allegedly novel structure as "interference eliminating means." This phrase does not appear in the specification. The claim recites that this "means" is to limit the response of the receiver to echoes from "actual" obstructions. The significance of the word "actual" is not explained in the specification. The claim does not define structure for eliminating the recording of all other than actual obstructions. It merely calls for "means" for doing so. Likewise, claim 15 (R. 598) defines the alleged novelty over Lehr and Wyatt as "resonance means * * * to produce therein a natural acoustical period of oscillation," and claim 17 (R. 598) calls for "means having a natural frequency of oscillation * * * to accent" echoes from "couplings and other obstructions." The word "resonance" does not appear anywhere in the specification, nor does the phrase "natural acoustical period of oscillation."

All of these phrases refer to the pipe 13 of adjustable length connecting the receiver to the well casing. There is no basis for assuming that in drawing these claims, Walker intended to cover the use of an electrical filter in the Lehr & Wyatt recorder or that the Patent Office intended to grant Walker a monopoly on such use. Claim 15 of patent 2,156,519 (R. 598), for example, shows that there was no such intention. The claim employs both

the word "resonance" and the word "acoustical" to describe the "means." The word "resonance," while used in electricity to define intensification of a particular frequency, is more commonly used to define intensification of sound. The word "acoustical" is not an electrical term at all.* Acoustics is the "science of sound, including its production, transmission and effects." (*Webster's New International Dictionary*, 2nd Ed., 1938).

The phrases used in the claims do not define the electrical filter used in Petitioner's Echo-Meter. Dr. Mackeown, professor of electrical engineering in the California Institute of Technology and in charge of the work there in radio, sound recording, electronics, etc. (R. 327), testified that an electrical filter is not a tuning device (R. 446, 447), is not resonant, even electrically (R. 362, 363, 364, 446), does not have a "natural frequency of oscillation" (R. 362, 457, 458) and does not amplify (R. 363, 364). It does not operate on the same principle as an electrical tuning device (R. 363, 364) and has nothing in common with a tuned pipe (R. 350, 353, 356). There is not one word of testimony anywhere in the record in contradiction of Dr. Mackeown's statements; nor is there one word of testimony anywhere in the record in contradiction of his testimony that an electrical filter has an entirely different mode of operation than an acoustically tuned pipe (R. 356). The Circuit Court of Appeals, in holding (R. 1603) that an acoustically tuned pipe is the equivalent of an electrical filter, quoted (R. 1603) state-

---

*"The Court: When you say 'experimenting with acoustical tuning,' you mean mechanical tuning? A. Mechanical tuning, that's right, your Honor."—Walker (R. 517).

ments of a Patent Office Examiner. We submit that consideration of an Examiner's statements for this purpose is improper. Proceedings in the Patent Office cannot properly be used to expand the claims of a patent. They can be used only to limit the claims. *Dwight & Lloyd Sintering Co.* v. *Greenawalt*, 27 Fed. (2d) 823, 832, (C. C. A. 2).

Moreover, the quoted statements of the Examiner were made in a different application, Serial No. 164,534 (Exhibit L. R. 953), after patent 2,156,519 had issued. Patent 2,156,519 issued May 2, 1939. The statements of the Examiner (R. 1046-1047, 1060), quoted (R. 1603) in the Court's opinion, were made March 29, 1941 (R. 1045), and April 11, 1942 (R. 1059). Neither statement was made by the Examiner who issued patent 2,156,519, nor by an Examiner skilled in the same art. The complaint in this suit was filed July 16, 1941 (R. 6). Thus the main statement as to equivalency was made after this suit had been filed. Counsel for Respondent had practically insisted that the Examiner make such a statement (See, for example, Walker's "Request for Further Explanation" of April 6, 1942, R. 1058, 1059). After patent 2,156,519 had issued, statements by an Examiner in another art and in another case are extrinsic and irrelevant on the question of the scope of the claims. Petitioner had no chance to cross-examine the Examiner as to these statements. They are not sworn testimony and cannot properly be used to rebut the sworn testimony in this record. The statements were not made as an interpretation of the claims here in suit, but were made as an additional ground for refusing claims in application Seriol No. 164,534.

The Examiner did not state that an electrical filter is the equivalent of an acoustical tuned resonator. The state-

ments of the Examiner quoted by the Court do not mention a filter. The Examiner said that "the equivalence of electrical tuning and mechanical tuning * * * was thought to be * * * generally recognized * * * " This is not even a statement that an electrical filter is the equivalent of electrical tuning. The only word anywhere in the record on that point is that an electrical filter is "entirely different" than electrical tuning (R. 352, 356, 448). The Circuit Court of Appeals apparently has confused an electrical filter with electrical tuning. The opinion states (R. 1603) that an electrical filter has "the property of amplifying certain vibrations and eliminating others." This is not correct. Tuning amplifies, but a filter cannot amplify (R. 315, 318, 363).

Regardless of expert opinion, the patent grant itself precludes broad interpretation. As has often been said, a patent is a contract.* Consideration for the grant is the disclosure to the public of "some substantial innovation." *Sinclair and Carroll Co., Inc.*, v. *Interchemical Corp.*, 325 U. S. 327, 89 L. Ed. 1644. Patent 2,156,519 in suit was obtained on the basis that the invention resided in "selection of the pipe 18 of approximately one-third of the length of the section or joint of tubing 5 * * * to produce magnified

---

*The specification and claims of a patent constitute the patent contract. *O. H. Jewell Filter Co.* v. *Jackson*, 140 Fed. 340 (C. C. A. 8); *Firestone Tire & Rubber Co.* v. *U. S. Rubber Co.*, 79 Fed. (2d) 948 (C. C. A. 6), (cert. den. 298 U. S. 679). A patent is a contract between the inventor and the government and is subject to the same general rules of construction that apply to other contracts. When its terms are plain, and the intention of the parties clearly manifest therefrom, they must prevail. *Goodyear Dental Vulcanite Co.* v. *Davis*, 102 U. S. 222, 26 L. Ed. 149.

or amplified peaks *e*." (Quoting from the specification R. 595, Col. 1, *ll* 64-69). There being no suggestion whatever of the use of an electrical filter, the specification and claims should not be construed to cover such use.

Disclosure of one device does not constitute consideration for a monopoly on an entirely different device.

> "The thing patented is the particular means devised by the inventor by which that result is attained, leaving it open to any other inventor to accomplish the same result by other means."
>
> —*Electric R. R. Signal Co.* v. *Hall Railway Signal Co.*, 114 U. S. 87, 29 L. Ed. 96, 99.

In *Koebel* v. *Coe*, 105 Fed. (2d) 784, the U. S. Court of Appeals for the District of Columbia (before Groner, Chief Justice, and Edgerton and Vinson, Associate Justices), affirmed the District Court on the grounds that a claim was broader than the invention because it included more than was disclosed. The Court of Appeals stated, "They cannot patent what they do not disclose." See also *Corning* v. *Burden*, 56 U. S. 252, 14 L. Ed. 683; *Fuller* v. *Yentzer*, 94 U. S. 288, 24 L. Ed. 103.

Proceedings in the Patent Office

Had Walker intended to have patent 2,156,519 cover the use of an electrical filter in the Lehr and Wyatt system, it would have been a simple matter to disclose that device in the specification. Walker had used an electrical filter in the echo recording system he had built to test out the Lehr and Wyatt system in 1935 (R. 516). His conception

of the idea of using an acoustical tuned pipe did not take place until March 6, 1937 (R. 196). Instead of making disclosure of electrical means in the application for patent 2,156,519, he filed a separate application on the electrical system with an electrical filter "for tuning" the electrical circuit to cause it to "respond more readily to echoes from selected obstructions" in the well (quoting from claim 15, R. 982), this application being Serial No. 164,534 (Exhibit L, R. 954). This application was filed September 18, 1937, only eleven days after application for patent 2,156,519 was filed.

The two applications were handled by different Examiners in the Patent Office. The application for the patent in suit went to Division 5, Class 181-0.5 (R. 1416), "Acoustics, Miscellaneous." Apparently, the Examiner in Division 5 made no search in the electrical signaling art. Neither the Tucker patent* (R. 1077) showing the hot wire microphone and the acoustical resonator, nor the Williams patent (R. 1089) showing an electrical sound detecting system having a filter connected to a microphone and an amplifier, nor any similar prior art, was cited.

Respondent's co-pending application Exhibit L, on the other hand, was examined in Division 42, Class 177 (R. 990), "Electric Signaling."

---

*The Circuit Court of Appeals, in its opinion, stated (R. 1600):

"The Tucker patent mentioned was among the examples of the prior art cited by the Examiner."

The Court was in error. The Tucker patent was not cited. The only prior patents cited were Batcheller 602,422, Taylor 1,847,636, and Lehr and Wyatt 2,047,974. See rejections (R. 1464, 1482).

The co-pending application contained the following claim:

> "15. In a system for receiving and translating pressure echoes for various obstructions in a well, pressure responsive means coupled to the well to be exposed to pressure variations therein, electrical means actuated by said pressure responsive means to vary electrical values in accordance with the variations of pressure received by said pressure responsive means, translating means for receiving said electrical variations and for describing an observable wave pattern corresponding to the patterns of the echo waves, and means interposed between said pressure responsive means and said translating means for tuning said electrical means to respond more readily to echoes from selected obstructions than to pressure variations emanating from other sources." (R. 982).

Had the Patent Office intended to grant Walker a monopoly on a system having an electrical recorder with electric tuning, this claim would have been allowed. Instead of allowing it, on April 5, 1939, which was prior to the issuance of patent 2,156,519, the Patent Office Examiner in Division 42 rejected this claim on the prior art.*

---

*In its Petition for the Writ of Certiorari herein, page 3, Petitioner stated that claim 15 (R. 982) of the co-pending application Serial No. 164,534, was rejected (R. 1002) as involving no invention over the prior art and canceled (R. 1003). Respondents, in their Brief in Opposition to the Granting of the Writ, page 11, stated:

> "What petitioner fails to say is that in the instant case, *there was no prior art upon which the electrical claims could be rejected* except Walker's own patent in suit." (Italics theirs).

Respondents' statement is not true. Claim 15 of application 164,534 was rejected on the prior Lehr and Wyatt patent in view of a prior patent to Rieber (R. 1000) and again on the Lehr and Wyatt patent alone (R. 1002). It was never rejected on the Walker patent in suit. The patent in suit had not yet issued when these rejections were made.

The Examiner's rejection included the following:

"Claim 15 is further rejected on Lehr *et al* alone. This claim differs from the reference only in the inclusion of a filter. But it is not invention broadly to use a filter wherever a filter is desirable." (R. 1002).

In response to this rejection, Walker cancelled claim 15 (R. 1003). Instead of controverting the rejection, he abandoned any attempts to obtain patent protection on the idea of adding a filter to the Lehr *et al.* system. A new claim 25 (R. 1006) was substituted for cancelled claim 15, but as explained to the Patent Office at the time, the new claim 25 was directed to something "more than any mere inclusion of a filter." (R. 1015).

This cancelled and abandoned claim 15 reads squarely upon Petitioner's Echo-Meter, if the interpretation of the terms of the claims in suit by the Circuit Court of Appeals is correct. The "pressure responsive means" is the Y-pipe, the housing and the microphone coupled to the well. The "electrical means actuated by said pressure responsive means" is the amplifier. The "translating means" is the electrical recorder. The "means for tuning" is the filter.

Unless the decision of the Circuit Court of Appeals is modified, Petitioner will be enjoined from doing the thing that the Patent Office records show is permissible as outside the scope of the monopoly the Patent Office intended to grant Walker.

The file wrapper of patent 2,156,519 (Exhibit T, R. 1415) shows that there was no intention on Walker's part,

or on the part of the Patent Office, to cover anything electrical in the claims. The rejections (R. 1464, 1482), by the Examiner of Division 5 handling Acoustics were chiefly based on the prior patents to Batcheller and Lehr and Wyatt. Respondent's counsel interviewed this Examiner several times (see reference to the interviews, R. 1498, 1512, 1531), and argued extensively (R. 1498-1535) that invention was involved in the Walker system because it made records, by which echoes from different obstructions were "distinguishable" (R. 1500). It was argued that the cited prior art devices, such as the Lehr *et al.* patent, were incapable of doing so and that "it is their absence from the prior art knowledge which defines the difference between success and failure of the system" (R. 1504).

The argument accompanying the submission of the claims points out what it is that enabled Walker to accomplish this result. The claims here in suit (R. 596-598) are claims 1, 13, 14, 15 and 17. These were presented late in the prosecution of the application. They were originally numbered 52 (R. 1496), 58 (R. 1528), 59 (R. 1529), 60 (R. 1529), and 62 (R. 1530), respectively. All were added by amendment after the rejections of earlier claims on Batcheller and Lehr and Wyatt. The claims here in suit define one of the elements as a "pressure responsive device," or a similar term. According to the specification (R. 592, Col. 1, *ll.* 26-28), the "pressure responsive device" is the apparatus 26-28), the "pressure responsive device" is the apparatus shown in Figure 5 (R. 590) of the Walker patent. It includes the diaphragm 23 and the associated housing and

other parts. Page 4 of the specification (R. 594, Col. 1, *l* 63 *et seq.*) describes how this apparatus may be adjusted to vary the sensitivity of the diaphragm 23 and thus "distinguish between echoes from different obstructions in the well" (R. 594, Col. 1, *ll.* 68, 69). The prior patent to Batcheller, while it had a diaphragm, did not disclose a pressure responsive device capable of being adjusted to accomplish this function. (See argument of counsel, R. 1476, 1477).

Original claim 20 (R. 1451) did not include a "pressure responsive device." This claim was cancelled when rejected on the prior art and claim 53 (R. 1497), which called for a "pressure responsive device," was substituted therefor. The remarks accompanying this change stated:

> "Claim 53 has been substituted for Claims 20, 21, 22 and 23 and is directed to the apparatus by which the applicant can produce impulses of different magnitude, which includes means for producing variable impulses and means for visually observing the movement of a pressure responsive device so as to determine when the distinguishable echoes are produced. This is a feature not contemplated in any of the prior art devices and this claim is also clearly allowable." (R. 1504, 1505).

Therefore the phrase "pressure responsive device" used in the claims defines something more than an ordinary microphone such as disclosed in the Lehr and Wyatt patent, which could not be adjusted to perform this function. Only by ignoring the file wrapper can the phrase "pressure responsive device" be construed to define a hot-wire micro-

phone. By adjusting Respondents' "pressure responsive device," slow or gradual changes in pressure can be recorded. A slow change in pressure would have no perceptible effect on an Echo-Meter record (R. 360). The hot-wire microphone responds only to a quick change in velocity — a "steep-front sound wave" (R. 623) such as that created by a gun shot.

In another respect, the file wrapper (Exhibit T, R. 1415) of the patent in suit imposes limitations in the claims in suit. Broad claims (such as original claim 27, R. 1454), not limited to tuning had been rejected (R. 1464) on Batcheller (R. 1065), and cancelled (R. 1466). In presenting claims 52, 58, 59, 60 and 62 (claims 1, 13, 14, 15 and 17 of the patent which are the claims in suit), it was represented to the Patent Office that the language of claim 58 specifies "all of the necessary elements for accomplishing the result of producing the echoes from the tubing collars which are distinguishable from each other" (R. 1532), that "claim 59 recites the same structure in more limited terms, specifying that this means or mechanism for permitting the distinguishable registration of the tubing collar echoes is an 'interference eliminating means' * * * as specified on page 20 of the original specification" (R. 1533); that "claim 60 defines the same subject but limits the mechanism to a resonance means, which produces a natural acoustical period of oscillation" (R. 1533), that claim 62 is directed to the feature "which has the peculiar characteristic that it has the natural frequency of oscillation which will result in the accenting of tubing collar echoes"

(R. 1533), and claim 52 (claim 1 of the patent) was classed with claims specific to an adjustable pipe (R. 1533, 1534).

The Court may properly consider "what the patentee said when he was making his application" to determine whether "the construction of the patent is confirmed by the avowed understanding of the patentee expressed by him, or on his (be)half, when his application for the original patent was pending." *Goodyear Dental Vulcanite Co.* v. *Davis*, 102 U. S. 222, 26 L. Ed. 149, 150.

If the file wrappers (Exhibit T, R. 1415 and Exhibit L, R. 953) are considered, it becomes clear that the patent in suit is directed to a system quite different from Petitioner's Echo-Meter.

It was old in the art to shoot a gun and record the echo with a diaphragm recorder (Batcheller, No. 602,422, R. 1065). It was old in the art to create a pressure impulse in a well by allowing gas to enter from a pressure cylinder and record the echo with a microphone, amplifier and electrical recorder (Lehr, No. 2,047,974, R. 1101). From the prior art, Walker selected the pressure cylinder of Lehr and the diaphragm recorder of Batcheller, and added an adjustable pipe to tune the recorder. Petitioner went just the other way. It selected the gun of Batcheller, the microphone of Tucker, and used the conventional electrical amplifier and recorder, such as disclosed in the Lehr patent and used by the Union Oil Company long before that. Where such differences exist between the structure of a patent, and the structure of the accused device, no infringement exists. *Electric R. R. Signal Co.* v. *Hall Railway Signal Co.*, 114 U. S. 87, 29 L. Ed. 96.

SUMMARY OF ARGUMENT

The claims in suit are invalid.

The Circuit Court of Appeals for the Ninth Circuit, by ruling that "means * * * for tuning * * *" in Claim 1 and like functional statements in Claims 13, 14, 15 and 17 of Patent 2,156,519 define the only novel element in the claims "with sufficient distinctness and clarity to comply with the statute" (R. 1600), has rendered a decision in direct conflict with the decision of this Court in *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, 82 L. Ed. 1402. The claims do not meet the requirements of R. S. Sec. 4888.

The claims in suit are not infringed.

The Circuit Court of Appeals for the Ninth Circuit, by ignoring the rejection, cancellation and abandonment of a claim in a co-pending application for patent, has so construed the claims in suit as to cause them to cover subject matter refused Respondents by the Patent Office and has imposed undue restrictions on the rules governing the construction of claims set forth in *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, 220, 221, 85 L. Ed. 132, 137, 138. Respondents are estopped from asserting title to the abandoned subject matter.

Conclusion

Respondents seek a monopoly on apparatus entirely different than that disclosed or intended to be covered by the patent grant. The claims of the patent should be held invalid because broader than the invention. If valid, they should be held not infringed by apparatus different from that disclosed in the patent.

ARGUMENT

The claims in the suit are invalid.

The requisites for definiteness in the specifications and claims of a patent are statutory. A patentee must describe his invention in:

> "* * * such clear, concise and exact terms as to enable any person skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct, compound and use the same; and in the case of a machine, he shall explain the principle thereof, and the best mode in which he has contemplated applying that principle, so as to distinguish it from other inventions; and he shall particularly point out and distinctly claim the part, improvement or combination which he claims as his invention or discovery."
>
> —Section 4888 of the Revised Statutes (U. S. C. title 35, sec. 33).

> "It seems to us that nothing can be more just and fair both to the patentee and to the public, than that the former should understand and correctly describe just what he has invented, and for what he claims a patent."
>
> —*Merrill* v. *Yoemans*, 94 U. S. 568, 24 L. Ed. 235, 237.

> "The statute requires the patentee not only to explain the principle of his apparatus and to describe it in such terms that any person skilled in the art to which it appertains may construct and use it after the expiration of the patent, but also to inform the public during the life of the patent of the limits of the monopoly asserted, so that it may be known which features may be safely used or manufactured without a license and which may not."

—*Permutit Co.* v. *Graver Corp.*, 284 U. S. 52, 60, 76 L. Ed. 163, 167.

"The courts in determining the questions of invention and infringement brought to them by respondent, no less than the parties-litigant, need and may insist upon the precision enjoined by the statute."

—*United Carbon Co.* v. *Binney & Smith Co.*, 317 U. S. 228, 232, 87 L. Ed. 232, 235.

In *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, 369, 82 L. Ed. 1402, 1405, this Court stated

"Recognizing that most inventions represent improvements on some existing article, process or machine, and that a description of the invention must in large part set out what is old in order to facilitate the understanding of what is new, Congress requires of the applicant 'a distinct and specific statement of what he claims to be new, and to be his invention.' Patents, whether basic or for improvements, must comply accurately and precisely with the statutory requirement as to claims of invention or discovery. The limits of a patent must be known for the protection of the patentee, the encouragement of the inventive genius of others and the assurance that the subject of the patent will be dedicated ultimately to the public. The statute seeks to guard against unreasonable advantages to the patentee and disadvantages to others arising from uncertainty as to their rights." * * *

The Circuit Court of Appeals seems to have set up a rule for testing the definiteness of claims to a combination different from that applicable to claims for a single element or specific product. In denying the petition for rehearing, the Circuit Court of Appeals stated:

"In its petition for rehearing appellant, Halliburton Oil Well Cementing Company, assumes that the court

in ruling on Walker's patent No. 2,156,519 failed to consider the cases of *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, and *Davis Sewing Mach. Co.* v. *New Departure Mfg. Co.*, 217 Fed. 775, particularly the first of these decisions. Halliburton is mistaken. In the General Electric case the claim considered was not one for a combination of elements, but a claim for a single element. Here, the claims are for a combination of elements." (R. 1614).

In his concurring opinion denying rehearing, Judge Denman stated:

"No case is cited in which such a combination of means alone has been sought and the case seems of novel import." (R. 1615).

We believe that there is no previous authority for the distinction made by the Court. The statutes do not authorize such a distinction. In fact, the statutes seem to require even greater particularity in a patent on a machine or combination of elements than in a patent on one of the other three classes of inventions listed as patentable in R. S. 4886 (U. S. C. title 35, sec. 31), for the statutes mention it specifically, stating:

"and in the case of a machine, he shall explain the principle thereof, and the best mode in which he has contemplated applying the principle, so as to distinguish it from other inventions."

—R. S. Sec. 4888 U. S. C. title 35, Sec. 33.

"The term 'machine' includes every mechanical device or combination of mechanical powers and devices to perform some function and produce a certain effect or result."

—*Corning et al.* v. *Burden*, 56 U. S. 252, 267, 14 L. Ed. 683, 690.

Several cases are in direct conflict with the ruling [149 Fed. (2d) 896, R. 1614, 1616] of the Ninth Circuit Court of Appeals in the present case that the doctrine of *General Electric* v. *Wabash*, 304 U. S. 364, does not apply to claims on a combination of elements. These conflicting cases are reviewed briefly here.

In *Rice* v. *Nash-Kelvinator Corp.*, 150 Fed. (2d) 457 (C. C. A. 6), decided since the Ninth Circuit Court of Appeals rendered its decision, a patent on a refrigeration machine was involved. Claim 3 called for a *combination* of old elements, a compressor, a condenser, an evaporator and pipe connections, with one new element, a capillary tube. The claim was thus identical in form with that of the claims in the case at bar. The Sixth Circuit Court of Appeals stated:

> "Claim 3 requires a capillary tube such as will maintain the predetermined ratio described above 'and minimize any tendency of the tube to clog, the said parts of the refrigerating machine and the refrigerant charge being so co-ordinated that the single capillary tube is adapted to function as the regulating device of the flow between the condenser and the evaporator and by reason of the said co-ordination the liquid level in the evaporator is maintained between narrow limits.'
>
> "These portions of the claims describe not the structure, but the function or purpose to be achieved by the tube. This practice has recently been condemned. *General Electric Co.* v. *Wabash Appliance Corporation*, 304 U. S. 364, 371, 58 S. Ct. 899, 82 L. Ed. 1402; *United Carbon Co.* v. *Binney & Smith Co.*, 317 U. S. 228, 234, 63 S. Ct. 165, 87 L. Ed. 232."
>
> —150 Fed. (2d) 460.

In another recent case, *Application of Horton et al.*, 151 Fed. (2d) 210, the Court of Customs and Patent Appeals had before it a number of claims on combinations of elements. These had been rejected by the Examiner and the Board of Appeals in the Patent Office because "their broad and indefinite language fails to make a clear distinction" over the prior art. The Court of Customs and Patent Appeals reversed the Patent Office tribunals as to some of the claims because they contained structural limitations, but it affirmed the Patent Office tribunals as to those claims which attempted to distinguish from the prior art only by functional limitations, the Court stating:

> "The board was further of opinion, as stated in its decisions, that the claims here on appeal do not define the 'generic novelty' of appellants' device in terms of structure, but rather in terms of function.
>
> "If the latter holding of the board is correct, the rejection should be sustained, since claims drawn to apparatus cannot be allowed unless they distinguish from the prior art in terms of structure. *In re Skaupy*, 67 Fed. (2d) 492, 21 C. C. P. A., Patents, 712; *In re Carr*, 120 Fed. (2d) 386, 28 C. C. P. A., Patents, 1240; *General Electric Co.* v. *Wabash Appliance Corp. et al.*, 304 U. S. 364, 370, 371, 58 S. Ct. 899, 82 L. Ed. 1402."
>
> —151 Fed. (2d) 213.

In *Kool Kooshion Mfg. Co.* v. *Mitchell Mfg. Co.*, 102 Fed. (2d) 37, (C. C. A. 8), a patent on a combination of several elements was involved. The Court stated:

> "Appellee urges that claim 3 is invalid as being indefinite in that it specifies no definite fabric enclosure nor any definite means of extending and holding extended the cushion. There is serious question

whether this criticism is not well founded under the doctrine of *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, 370-375, 58 S. Ct. 899, 82 L. Ed. 1402."

—102 Fed. (2d) 38.

In *Allen-Bradley Co.* v. *Erie Resistor Corp.*, 104 Fed. (2d) 150 (C. C. A. 3), the following claim was involved:

"7. As an article of manufacture, an electrical resistor unit having as ingredients thereof, a non-conducting material serving as a filler, a suitable material affording a binder, and carbon black calcined to substantially graphitizing temperature."

—104 Fed. (2d) 151.

The Court stated:

"The appellant therefore is caught between the horns of a dilemma. If the phrase 'to substantially graphitizing temperatures' as used in the claims be construed to mean what we think Power and Bradley must have intended it to mean, viz., calcining temperatures of not less than 1927° Centigrade, we must also hold that the appellee's processes do not infringe the three claims now under discussion. If, upon the other hand, we do not so interpret the phrase referred to in the claims in question, there is no doubt that the claims are invalid for want of definiteness. *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, 371, 58 S. Ct. 899, 82 L. Ed. 1402, 1407. (Other cases cited). So regarding, and without passing upon the validity of the disclosures of the patent over the prior art, we concur in the ruling of the District Judge that claims 4, 7, and 8 of the patent are not infringed by the appellee's processes."

—104 Fed. (2d) 152.

In *Hazeltine Corporation* v. *Emerson Television-Radio, Inc.*, 129 Fed. (2d) 580, (C. C. A. 2) the following claim to a combination was involved:

> "5. The combination of a large conical diaphragm, with a casing open at opposite ends disposed about the edge of said diaphragm and providing an open sound chamber at the rear of said diaphragm serving to enhance the operation thereof throughout its frequency range."
>
> —129 Fed. (2d) 581.

The Court stated:

> "The term 'large diaphragm' had an accepted meaning in the art. Otherwise claims 1, 3 and 5, which call for a 'large' diaphragm, might well be thought so vague as to be invalid. Cf. *B. B. Chemical Co.* v. *Cataract Chemical Co.*, 2 Cir., 122 Fed. (2d) 526, 530; *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, 58 S. Ct. 899, 82 L. Ed. 1402."
>
> —129 Fed. (2d) 581.

See also *In Re Cohen*, 133 Fed. (2d) 924, 928, 929, (C. C. P. A.); *Timken Detroit Axle Co.* v. *Cleveland Steel Products Corp.*, 148 Fed. (2d) 267, 269, (C. C. A. 6).

Except for the ruling of the Ninth Circuit Court of Appeals in the case at bar, we have found no case holding that the doctrine of *General Electric* v. *Wabash Appliance Corp.*, 304 U. S. 364, should be limited, in its application to claims on a *single element*. It has universally been held that the case sets forth the doctrine "that functional statements cannot be availed of to define over the prior art." *Mead Johnson & Co.* v. *Hillman's Inc.*, 135 Fed. (2d) 955, 958, (C. C. A. 7). As stated by the Court of Appeals for

the District of Columbia in *Minnesota Mining & Mfg. Co.* v. *Coe*, 113 Fed. (2d) 512, 513, in an opinion by Associate Justice Rutledge:

> "It has been held that a description by function does not comply with the statutory requirement that the inventor 'shall particularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery.' Rev. Stat. Sec. 4888, 35 U. S. C. (1934) Sec. 33, 35 USCA Sec. 33; *General Electric Co.* v. *Wabash Co.*, 1938, 304 U. S. 364, 58 S. Ct. 899, 82 L. Ed. 1402; *Koebel* v. *Coe*, 1939, 70 App. D. C. 261, 105 Fed. (2d) 784."

This Court has not heretofore limited the doctrine to the "single element" class of invention involved in the *General Electric* v. *Wabash* case. In *Universal Oil Products Co.* v. *Globe Oil & Ref. Co.*, 322 U. S. 471, 484, 88 L. Ed. 1399, 1407, the case is cited and the doctrine applied to process claims.

The Ninth Circuit Court of Appeals itself seems to be in doubt as to the application of the doctrine of the *General Electric* v. *Wabash* case to claims on a combination of elements. In *John Bean Mfg. Co.* v. *Creagmile*, 123 Fed. (2d) 182, claims to a combination were involved. In the opinion written by Judge Denman, there is an analysis of the claims there involved similar to Judge Denman's analysis [149 Fed. (2d) 896, R. 1615] of one of the claims in the case at bar, and the opinion then states:

> "We believe there is grave doubt as to whether or not these claims are valid on their face on the ground of their failure to make disclosure sufficiently definite to satisfy the requirements of R. S. 4888, 35 USCA Sec. 33. Cf. *General Electric Co.* v. *Wabash Appliance*

> *Corp.*, 304 U. S. 364, 368-370, 58 S. Ct. 899, 82 L. Ed. 1402. However, we have resolved our doubt in favor of examining into the question of novelty and anticipation."
>
> —123 Fed. (2d) 184.

See also *Farmers Cooperative Exchange* v. *Turnbow*, 111 Fed. (2d) 728 (C. C. A. 9), where claims to a combination were held invalid because they used "conveniently functional language at the exact point of novelty."

The claims involved in *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, would not have been rendered more definite if they had called for a *combination* of the old parts of the lamp with a new filament instead of calling for "a filament *for* electric incandescent lamps."

Conversely, there is no real difference between the claims in the present case for a *combination* of parts of the old Lehr and Wyatt device with means for tuning one part, and a claim directed merely to means *for* tuning the receiver of the Lehr and Wyatt device.

The requirements for definiteness should not be evaded by reciting inconsequential matter in a claim. All Walker has added to the Lehr and Wyatt system is the acoustically tuned pipe. This does not affect the "means communicating with said well for creating a pressure impulse in said well" (referred to as element B by Judge Denman, R. 1615). It is an improvement in the recorder only.

> "The improvement of one part of an old combination gives no right to claim that improvement in combination with other old parts which perform no new function in the combination."

—*Lincoln Engineering Co.* v. *Stewart-Warner Corp.*, 303 U. S. 545, 549, 550, 82 L. Ed. 1008, 1010.

See also the discussion in the opinion by Associate Justice Vinson in *Krause* v. *Coe*, 120 Fed. (2d) 717, U. S. Court of Appeals for the District of Columbia.

If there is a difference of any importance between the form of the claims in the Walker patent in suit and those condemned in *General Electric Co.* v. *Wabash Appliance Corp.*, it is a difference which brings the claims in suit squarely within the ruling in *Lincoln Engineering Co.* v. *Stewart-Warner Corp.* The claims are to an old combination.

But the use of the word "means" to define the novel element in combination claims does not, as Judge Denman thought, raise a question of novel import. In 1907, in the case of *Tyden* v. *Ohio Table Co.*, 152 Fed. 183, the Circuit Court of Appeals for the Sixth Circuit had before it a patent on a pedestal table. Claim 1 of the patent was for a combination of elements. The parts of the table were set forth in some detail, but the novel element was defined only by the "means" followed by a recital of functions. The Court, speaking through Judge Lurton, held that the claim was too broad, stating:

> "It claims all means for locking and holding the pedestals and is substantially a claim for a function. It cannot be upheld and must be held void."

Later, the rule of *Tyden* v. *Ohio Table Co.* was again considered by the Circuit Court of Appeals for the Sixth Circuit. In *Davis Sewing Machine Co.* v. *New Departure*

Mfg. Co., 217 Fed. 775, combination claims, which used the word "*mechanism*" instead of "*means*" to define certain elements, were under consideration. *It was held that such a word was not objectionable where used in the claim to define other than the nove' element, but that the use of the all-inclusive term was objectionable where used to define the exact point of novelty.* The opinion by Judge Denison states:

> "Reliance is also placed upon the opinion of this Court, speaking by Judge (afterwards Mr. Justice) Lurton, in *Tyden* v. *Ohio Table Co.*, 152 Fed. 183, 81 C. C. A. 425. In this case, the claim calling for 'means' was held invalid because it covered all means for accomplishing the result, and so was functional. We do not question the application of the rule as made to the facts of that case; but we do not understand that a claim is functional and invalid merely because one of its specified elements is 'means,' as in the Tyden Case, or 'mechanism,' as in the present case. This result may or may not follow, depending upon whether the all-inclusive term is used with reference to the element or subcombination which is the real point and gist of the invention, or whether it is used with reference to elements or parts of the combination already well known and designed only to co-operate with the new element in order to make a completely operative unit. In other words, where used with reference to the exact point of novelty, 'means' or 'mechanism' may expose the claim to attack on the ground that it is functional; in that respect, each case will present a problem by itself. But where used with reference to the make-up of the field in which the real invention finds its usefulness or with reference to the connecting parts which permit the salient novelty of the invention to accomplish its function, these words are

only a convenient formula of the broadest equivalency of which the real invention permits."

—217 Fed. at 782-783.

Respondents rely upon *Continental Paper Bag Co.* v. *Eastern Paper Bag Co.*, 210 U. S. 405, 52 L. Ed. 1122, in support of their contention that it is proper to define the novel element in a claim to a combination by reciting only its function. The case does not support this contention. The combination claims in that case called for:

(1) "A rotating cylinder provided with one or more pairs of side forming fingers.

(2) "A forming plate also provided with side forming fingers.

(3) "Means for operating said fingers at definite times.

(4) "Operating means for the forming plate adapted to cause the said plate to oscillate."

—(Quoting from Claim 1, 210 U. S. 417, 52 L. Ed. 1127).

There are two clauses in this claim which define structure in some detail and there are two clauses which are purely functional. Whether the claim complies with the statute depends upon which of these clauses is directed to the novel elements of the combination. It was held that the novelty resided in the combination of the rotating cylinder and the forming plate, which were described structurally in the claim.

"The circuit court said that the 'pith' of the invention 'is the combination of a rotating cylinder with means for operating the forming plate in connection therewith, limited, however, to means which cause the plate to oscillate about its rear edge on the surface

thereof,' and distinguished the invention from the prior art, as follows: 'Aside from the cylinder and the forming plate oscillating about its rear edge, everything in these claims (the claims of the patent) is necessarily old in the arts.' It was this peculiar feature of novelty, it was said, which clearly distinguished it from all that went before it. This conclusion was in effect affirmed by the circuit court of appeals. The latter court said that the folding of the bottoms of S. O. S. paper bags had been accomplished in the prior art both by a folding plate reciprocating upon a plane, and by the operation of fingers upon a cylinder. The folding plate and the cylinder had never been combined. * * *

"Counsel, however, contends that the circuit court, in its decision, virtually gave Liddell a patent for a function by holding that he was entitled to every means to cause the forming plate to oscillate about its rear edge. * * *

"The claim is not for a function, but for mechanical means to bring into working relation the folding plate and the cylinder. This relation is the very essence of the invention, and marks the advance upon the prior art."

—*Continental Paper Bag Co.* v. *Eastern Paper Bag Co.*, 210 U. S. 405, 420, 421, 422, 52 L. Ed. 1122, 1129.

The rule established by the "Paper Bag Case" is: A combination claim defining novel elements by recitations of their structure is not rendered functional merely because other elements not directed to the exact point of novelty are defined as "means" for accomplishing a given function. The "Paper Bag Case" was so interpreted in *Davis Sewing Machine Co.* v. *New Departure Mfg. Co.*,

217 Fed. 775, (C. C. A. 6), which interpretation has been followed ever since. In the *Davis Sewing Machine Co.* case the Court stated:

"In the latest reported decision touching this point, Paper Bag Patent Case, 210 U. S. 405, 422, 28 Sup. Ct. 748, 752 (52 L. Ed. 1122), the claim called for the combination of a rotating cylinder, forming plate, and 'operating means for the forming plate adapted to cause the said plate to oscillate about its rear edge etc.' (The claim included other mention of 'means' as elements, but this is the one to which the opinion refers.) It was argued that, by extending the patent to cover a device in which the defendants used very different means of causing a forming plate to oscillate about its rear edge, the court below had given the patentee a patent for a function. The Supreme Court held, in effect, that the use of these general terms is not objectionable in cases where the element so identified serves to provide a 'working relation' for what may be called the more primary elements of the combination. Mr. Justice McKenna says:

"'The distinction between a practically operative mechanism and its function is said to be difficult to define. Robinson on Patents, Sec. 144 *et seq.* It becomes more difficult when a definition is attempted of a function of an element of a combination which is the means by which other elements are connected and by which they coact and make complete and efficient the invention. But abstractions need not engage us. The claim is not for a function, but for a mechanical means for bringing into working relation the folding plate and the cylinder.'

"The Patent Office practice, in the shaping of claims with reference to these phrases, has vacillated. After some of the early court decisions disapproving the par-

ticular uses of these words which were involved in the cases decided, the Patent Office was inclined to forbid their use; but this confusion later settled down into the clearly established rule that these words would not be permitted where the novelty of the invention was in the specific mechanism to which they were intended to refer, but would be approved when they described 'mere adjunctive devices which connect or give co-operation to the various elements or features of the invention, but are in themselves no actual controlling part of it.' *Ex parte Paige*, 40 O. G. 807, 810; *Ex parte Pacholder*, 51 O. G. 295; *Ex parte* Halfpenny, 73 O. G. 1135. Pursuant to this rule regulating the 'substantive' and the 'adjunctive'—which we consider only another form of words for the distinction we have expressed—the great majority of patents during the last few years have contained claims identifying certain elements as for 'means,' 'mechanism,' 'devices,' etc."

—217 Fed. 783, 784.

The rule of *Davis Sewing Mach. Co.* v. *New Departure Mfg. Co.* has been cited with approval in many later cases. In some cases, as in *White Tool and Supply Co.* v. *Air Reduction Co.*, 48 Fed. (2d) 720, (C. C. A. 6); *Buono* v. *Yankee Maid Dress Corp.*, 77 Fed. (2d) 274, (C. C. A. 2); and *General Tire and Rubber Co.* v. *Fisk Rubber Corp.*, 104 Fed. (2d) 740, (C. C. A. 6), it has been cited to show that the use of the word "means" in a combination claim to define *other than the exact point of novelty* does not render the claim functional or invalid. In other cases, as in *Heidbrink* v. *Hardessen Co.*, 25 Fed. (2d) 8, (C. C. A. 7); *Goodwin* v. *Carloss Co.*, 116 Fed. (2d) 644, (C. C. A.

6); *In re Tucker*, 46 Fed. (2d) 214, (C. C. P. A.); *In re Ferguson*, 83 Fed. (2d) 693, (C. C. P. A.); and *In re Spitzglass*, 96 Fed. (2d) 1002 (C. C. P. A.); it has been cited to show that the word "means" renders a claim functional *where it is directed to the novel element.* In still other cases, such as *Hollingshead Co.* v. *Bassick Mfg. Co.*, 73 Fed. (2d) 543 (C. C. A. 6); *Firestone Tire and Rubber Co.* v. *United States Rubber Co.*, 79 Fed. (2d) 948 (C. C. A. 6) (Cert. denied 298 U. S. 679), it has been cited in support of a holding of non-infringement, the word "means" in combination claims being held to cover only the actual means described in the specification.

The soundness of the rule of the *Davis Sewing Machine* case has never been questioned. *Walker on Patents* (Deller's Ed.) Vol. 2, page 790, cites no other case under the heading, "Use of 'means' or 'mechanism,' etc., in claims," the author stating:

> "The interpretation to be given to such words as 'means,' 'mechanism,' etc., when used in claims, was fully discussed in *Davis Sewing Mach. Co.* v. *New Departure Mfg. Co.*, 217 Fed. 775, 782-784, C. C. A. 6 (1914), by Judge Denison. Because of the comprehensive nature of the discussion, the opinion is quoted in full: * * * "

In *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, this Court cited the *Davis Sewing Machine* case in support of a ruling condemning the use of conveniently functional language at the exact point of novelty in a claim. This Court, speaking through Mr. Justice Reed, said:

"The claim uses indeterminate adjectives which describe the functions of the grains to the exclusion of any structural definition, and thus falls within the condemnation of the doctrine that a patentee may not broaden his product claims by describing the product in terms of function. (*Holland Furniture Co.* v. *Perkins Glue Co.*, 277 U. S. 245, 256-258, 72 L. Ed. 868, 872, 873, 48 S. Ct. 474, and cases cited). Claim 25 vividly illustrates the vice of a description in terms of function. 'As a description of the invention it is insufficient and if allowed would extend the monopoly beyond the invention. (277 U. S. at 258). The Court of Appeals for the Ninth Circuit relied on the fact that the description in the claims is not 'wholly' functional. 80 Fed. (2d) 958, 963. But the vice of a functional claim exists not only when the claim is 'wholly' functional, if that is ever true, but also when the inventor is painstaking when he recites what has already been seen, and then uses conveniently functional language at the exact point of novelty. [See *Gynex Corp.* v. *Dilex Institute*, (C. C. A. 2d), 85 Fed. (2d) 103, 105; *Davis Sewing Machine Co.* v. *New Departure Co.*, (C. C. A. 6th), 217 Fed. 775, at 782.]"

—304 U. S. at 371, 82 L. Ed. at 1406-1407.

Both lower courts have found that there is but one novel element in the combination claimed in the patent in suit, this being the tuned acoustical resonator. The District Court found that:

"5. Prior to the patents in suit it was not new to fire a gun into a pipe and mechanically record the echo from an obstruction in the pipe and it was not new to inject into a well casing a charge of gas from a cylinder of gas under pressure and record electrically the echoes from obstructions in the well.

"6. Patent No. 2,156,519 is an apparatus patent and the apparatus disclosed includes mechanism for creating in the well a pressure wave caused by the sudden introduction of pressure into the well casing or the sudden release of pressure from the casing, a tuned acoustical resonator for accenting reflections from tubing collars or other apparatus or equipment in the well which diminishes or enlarges the annular space in the well at known regular intervals, a diaphragm actuated by pressure caused by the echoes and a mechanical, optical translating and recording mechanism for recording the echoes upon a tape together with mechanism for recording on the tape time intervals. This apparatus differs from and is an improvement over the prior art in the incorporation in such apparatus of a tuned acoustical means which performs the function of a sound filter as described in claims 1, 13, 14, 15 and 17."

—Findings of Fact (R. 28, 29).

The Circuit Court of Appeals stated:

"The trial court found that the only part of this patent constituting invention over the prior art is the 'tuned acoustical means which performs the functions of a sound filter.' It will be noted that Walker's acoustical tuned resonator is a purely mechanical device.

* * * * * * * * * * * *

"While Lehr and Wyatt suggest an amplifier, they neither suggest nor claim any device which would enable the operator to tune up certain desirable echoes while tuning out undesirable ones."—(R. 1599, 1600).

Claim 1 (R. 596) of patent 2,156,519 here in suit defines the part found below to constitute the only novel element as "means associated with said pressure responsive device

for tuning said receiving means to the frequency of echoes from the tubing collars." The particularity with which the other elements are defined is not important. When the exact point of novelty is reached only the function is recited. The claim in effect says merely: I claim means for tuning the receiver of a known echo depth measuring system to the frequency of echoes from the tubing collars.

Likewise, claim 13 (R. 597) of patent 2,156,519 defines the novel element only as "means associated with said receiving and registering means to accent the registration of tubing coupling echoes." No structure whatever is recited —only the function of some undefined means. Likewise, claim 14 (R. 598) defines the novel element only as "interference eliminating means;" claim 15 (R. 598) defines it as "resonance means associated with said receiving and registering means to produce therein a natural acoustical period of oscillation;" and claim 17 (R. 598) defines it as "means having a natural frequency of oscillation so related to the frequency of the echoes from said tubing couplings as to accent the registration of said echoes."

No one reading these claims can tell what this "means" is. This "means" includes everything that can perform the function.

The indefiniteness of these claims is not cured by the specification. In *General Electric Co. v. Wabash Appliance Corp.*, the Court said further:

> "The product claims here involved cannot be validated by reference to the specification. Assuming that in a proper case a claim may be upheld by refer-

> ence to the descriptive part of the specification in order to give definite content to elements stated in the claim in broad or functional terms, the specification of the Pacz patent does not attempt in any way to describe the filament, except by mention of its coarse-grained quality."
>
> —304 U. S. at 373, 82 L. Ed. at 1407.

In the same way, in the case at bar, the specification of patent 2,156,519 throws no light on the functional language of the claims. The following terms are not used in the specification: "means to accent," "interference eliminating means," "resonance means," "natural acoustical period of oscillation" or "natural frequency of oscillation."

In *General Electric Co.* v. *Wabash Appliance Corp.*, the Court said further:

> "The inventor must 'inform the public during the life of the patent of the limits of the monopoly asserted, so that it may be known which features may be safely used or manufactured without a license and which may not.'"
>
> —304 U. S. at 369, 82 L. Ed. at 1405.

No one having only patent 2,156,519 before him is apprised that these claims cover an electrical filter in the Lehr and Wyatt electrical system. No electric recorder with or without a filter is either described or shown. An entirely different application for patent (Exhibit L, R. 953) was prosecuted by Walker on the electrical recorder with a filter. The all-inclusive, purely functional clauses on the only novel element in the claims in suit do not "particularly

point out" the improvement, and the specification does not describe the improvement in "full, clear, concise and exact terms," as required by R. S. Sec. 4888, if the improvement consists in putting an electrical filter in the prior Lehr and Wyatt system.

Insofar as they attempt to define the novelty of the alleged invention, the claims are but inaccurate suggestions of the functions of the acoustical resonator.

> "The statutory requirement of particularity and distinctness in claims is met only when they clearly distinguish what is claimed from what went before in the art and clearly circumscribe what is foreclosed from future enterprise. A zone of uncertainty which enterprise and experimentation may enter only at the risk of infringement (of) claims would discourage invention only a little less than unequivocal foreclosure of the field."
>
> —*United Carbon Co.* v. *Binney & Smith Co.*, 317 U. S. 228, 236, 87 L. Ed. 232, 237.

The language of *Burr* v. *Duryee*, 68 U. S. 531, 17 L. Ed. 650, 657, 658, is applicable:

> "A machine is a concrete thing, consisting of parts, or of certain devices and combination of devices. The principle of a machine is properly defined to be 'its mode of operation,' or that peculiar combination of devices which distinguishes it from other machines. A machine is not a principle or an idea. The use of ill defined abstract phraseology is the frequent source of error. It requires no great ingenuity to mystify a subject by the use of abstract terms of indefinite or equivocal meaning. Because the law requires a patentee to explain the mode of operation of his peculiar machine, which distinguishes it from others, it does

not authorize a patent for a 'mode of operation as exhibited in a machine.' * * *

"No one who reads the two specifications, or inspects the two machines, can aver that they contain the same combination of mechanical devices, or substantially the same, to produce the desired effect. Not one of the devices or its equivalent, used in the one is to be found in the other, nor is its mode of operation the same. The argument used to show infringement assumes that every combination of devices in a machine which is used to produce the same effect, is necessarily an equivalent for any other combination used for the same purpose. This is a flagrant abuse of the term 'equivalent.' * * * In the case of *McCormick* v. *Talcott*, 61 U. S. 402, 15 L. Ed. 930, 931, we have said: 'If the invention claimed be itself but an improvement on a known machine by a mere change of form or combination of parts, the patentee cannot treat another as an infringer who has improved the original machine by use of a different form, or combinations performing the same functions. The inventor of the first improvement cannot invoke the doctrine of equivalents to suppress all other improvements which are not colorable invasions of the first.'"

The claims in suit are not infringed.

If there is one principle clearer than another in patent law, it is that "the claims are to be interpreted in the light of the specifications and drawings." *Huntman Stabilizer Corp.* v. *General Motors Corp.*, 144 Fed. (2d) 963 (C. C. A. 3), Cert. Denied, 3223 U. S. 782, 89 L. Ed. 624.

See also:

The Incandescent Lamp Patent, 159 U. S. 465, 40 L. Ed. 221;

Schriber-Schroth Co. v. *Cleveland Trust Co.*, 305 U. S. 47, 57, 83 L. Ed. 34, 39;

Century Electric Co. v. *Westinghouse Electric & Mfg. Co.*, 191 Fed. 350, 354, (C. C. A. 8).

To establish infringement, it must be shown that the accused device is the same as that of the patent in suit or the equivalent. *Union Water-Meter Co.* v. *Desper*, 101 U. S. 332, 25 L. Ed. 1024.

To be the equivalent, *three requirements must be met.*

> "To sustain the charge of infringement the infringing device must be substantially identical with the one alleged to be infringed in (1) the result attained; (2) the means of attaining the result; and (3) the manner in which its different parts operate and co-operate to produce that result. If the devices are substantially different in either of these respects the charge of infringement is not sustained."
>
> —*Electric Protection Co.* v. *American Bank Protection Co.*, 184 Fed. 916, 923, (C. C. A. 8).

In the present case:

1. There is not the same means. For example, a hot-wire microphone is not the same as the diaphragm of the patent (R. 341, 342). One is electrical; the other is mechanical. One does not respond to pressure pulses; the other does (R. 346, 358, 361). There is no interchangeability (R. 347). Interchangeability is an important test of identity of means. *Miller* v. *Eagle Mfg. Co.*, 151 U. S. 186, 208, 38 L. Ed. 121, 131.

2. There is not the same operation. For example, Petitioner's means for eliminating extraneous noises from being recorded does not operate in the same way as

Walker's tuning pipe (R. 356). The tuning pipe amplifies the sound waves before they affect the receiver in any way (R. 355). An electrical filter does not affect the sound waves (R. 349, 456, 656), but changes the characteristics of an electrical amplifier (R. 357) by decreasing undesirable electrical currents created in the microphone (R. 363, 456). The filter does not amplify (R. 315, 318, 363). It is not "resonant" (R. 351, 352, 363), does not have a "natural acoustical period of oscillation" (R. 317, 457), and does not "accent" (R. 363). The Court is not even called upon to decide whether an electrical tuning device is the equivalent of a mechanical tuning device, because a filter is not a tuning device (R. 351, 352, 356, 357, 447, 448). The filter and the acoustical tuner of the patent are "entirely different in their mode of operation" (R. 356). The principle of law applies, that where the *mode of operation* of the accused machine is substantially different from that of the patent, infringement cannot exist. *Field* v. *DeComeau*, 116 U. S. 187, 29 L. Ed. 596; *Yale Lock Mfg. Co.* v. *Sargent*, 117 U. S. 373, 29 L. Ed. 950; *Universal Oil Products Co.* v. *Globe Oil & Ref. Co.*, 322 U. S. 471, 485, 88 L. Ed. 1399, 1407.

> "If the device of the respondent shows a substantially different mode of operation, even though the result of the operation of the machine remains the same, infriengement is avoided." —*Cimiotti Unhairing Co.* v. *American Fur Ref. Co.*, 198 U. S. 399, 414, 49 L. Ed. 1100, 1107.

3. There is not the same result. The records obtained are not the same. While the graphs obtained with the Echo-Meter, like those obtained with the apparatus of the

patent in suit, are used to determine fluid level, they are not the same as those obtained when using the apparatus of the patent. The differences were fully explained at the trial by Walker (R. 173, 182, 183, 212, 213), by Dr. Mackeown (R. 341-343, 358, 361, 362, 365, 415), and by Cornes (R. 308, 309). The graphs are different because of the differences in structure of the devices, particularly the use of a "non-directional" hot-wire microphone instead of a "directional" diaphragm. The sketch (Exhibit 29, R. 781), copied from a drawing Respondent Walker made on a blackboard while he was testifying (R. 240), shows the different kinds of records obtained by pressure and rarefaction waves with a "directional mike" or diaphragm, and a "non-directional mike," such as a hot-wire microphone (R. 212, 213). The diaphragm of the patent responds differently to positive and negative pulses, and because its "sensitivity of response" can be controlled (Patent 2,156,519, R. 593, Col. 1, *l.* 75), it makes a record on which each obstruction produces a "typical desired configuration" (*Idem*, R. 594, Col. 2, *l.* 24), so that one can "distinguish between echoes from different obstructions in the well" (*Idem*, R. 594, Col. 1, *ll.* 68, 69). All of the echoes recorded by Petitioner's device are alike and are not distinguishable due to their configuration (R. 477-479). Petitioner's microphone is not responsive to pressure (R. 341, 342, 343, 344, 358). It is responsive to movement or velocity of gas through it (R. 346, 658). A diaphragm in a vessel responds to a pressure change whether there is gas movement or not, but a hot-wire microphone does not do so (R. 360). Until Walker developed his "directional" diaphragm, he was "lost in a

maze."* We submit that there cannot be "substantially the same result" under the law where the differences are as well recognized as they are here.

In discussing the question of infringement, the Circuit Court of Appeals said (R. 1601, 1602):

> "Halliburton's argument of non-infringement is based primarily on the indisputable fact that it uses an electrical apparatus, whereas Walker's is mechanical. Where different means are used to accomplish the same end or to perform the same function, the question of infringement depends upon the mode of operation as well as on the sameness of the result. Cf. Walker on Patents (Deller's Ed.) Vol. 3, pp. 1745, 1750. While identity of result is of course not a sufficient test of infringement, nevertheless an infringing device, generally speaking, is one which 'does the same work in substantially the same way and accomplishes

---

*Walker testified that in developing his device he discarded the idea of using a hot-wire microphone.

"Mr. Mattingly:

Q. Did you attempt to use the hot wire microphone?

A. No, I did not think it possessed the proper characteristics. It had no directional properties. * * *

Q. Does a hot wire microphone have the property of distinguishing between a constriction in the well and an enlargement in the well?

A. It does not. * * *

By the Court:

Q. A hot wire is not (satisfactory)?

A. It is not. * * *

Mr. Mattingly:

Q. Then these two types of obstructions, one of which constricts, and the other an enlargement; would be registered by the hot-wire microphone as though they were both constrictions, is that right?

A. That is right. * * * We have a large number of reflections from many of the wells, and if we are not able to identify those by the direction in which they are recorded, we are just lost in a maze; we don't know which is the fluid level." (R. 173-176).

substantially the same result.'* Walker on Patents (Deller's Ed.) Vol. 3, pp. 1707, 1751. The question is whether Halliburton's device is substantially the equivalent of Walker's."

Even if the Court were correct in finding that substantially the same result is obtained, the opinion is not sound. It holds that equivalency may exist between quite different devices if they have the same mode of operation, function and result. This is not the law. The pages of Deller's Edition of Walker on Patents, relied upon by the Court, do not support its ruling. On page 1707 of Walker, it is stated:

"Sec. 469. Tests of Equivalency. Identity of Result. Similarity or identity of result is not a sufficient test to show infringement, where there was a variation in the means used *(Stebler* v. *Porterville Citrus Assn.*, 248 Fed. 927, C. C. A. 9; *Conrader et al.* v. *Judson Governor Co.*, 238 Fed. 349) * * *."

On page 1745 of Walker it is stated:

"Sec. 495. Tests of Infringement of Machine or

---

*The quotation is from the text of Walker on Patents, Deller's Ed., Vol. 3, page 1751. The full statement of the textbook is:

"But if the mode of operation is substantially the same, it does not follow that the charge of infringement must be affirmed. (*Diamond Drill & Mach. Co.* v. *Kelly Bros.*, 120 Fed. 289 (1903); *E. Van Noorden Co.* v. *Cheney Co.*, 75 Fed. (2d) 298, 300 (C. C. A. 1) 1934). In that case the question must be decided by some additional criterion. To establish a claim of infringement, the facts must be subjected to several successive tests. If the case fails on either of those tests, no further inquiry need be made; but an infringement cannot be affirmed till all those tests have been applied and have been withstood.

"The first of these is that which relates to identity of mode of operation. It is therefore important to know wherein this requisite identity consists. It may be said in general that an infringing device is one which does the same work in substantially the same way and accomplishes substantially the same result."

Manufacture. Comparative Results and Mode of Operation. The respective results of a machine or manufacture covered by the claim of a patent, and of a machine or manufacture alleged to infringe that claim, do not furnish a criterion by which to decide the question of infringement. [*Westinghouse* v. *Boyden Power-Brake Co.*, 170 U. S. 537 (1898).]" (Other cases cited.)

On page 1746 of Walker it is stated:

"Those results may be identical, while the mode of operation and the means by which the result is secured are different. (*Electric Signal Co.* v. *Hall Signal Co.*, 114 U. S. 87, 29 L. Ed. 96.)" (Other cases cited.)

"Any person may accomplish the result performed by a patented thing without infringing the patent, if he uses means substantially different from those of the patent. [*O'Reilly* v. *Morse*, 15 Howard (56 U. S. 62 (1853).]" (Other cases cited.)

"To hold the contrary of this rule would be to retard and not to promote the progress of the useful arts. [*Smith* v. *Downing*, 1 Fish. 64, Fed. Cas. No. 13,036 (1850).]"

The established rule is that to find equivalency there must be, in addition to identity of mode of operation and result, "substantially the same or similar means." This is the rule of *Westinghouse* v. *Boyden Power-Brake Co.*, 170 U. S. 537, 568, 42 L. Ed. 1136, 1147, in which this Court said:

"But even if it be conceded that the Boyden device corresponds with the letter of the Westinghouse claims, that does not settle conclusively the question of infringement. We have repeatedly held that a charge of infringement is sometimes made out, though the letter of the claims be avoided. *Union Paper Bag Mach-*

ine Co. v. *Murphy*, 97 U. S. 120 (24 L. Ed. 935); *Ives* v. *Hamilton*, 92 U. S. 431 (23 L. Ed. 496); *Morey* v. *Lockwood*, 75 U. S. 8 Wall. 230 (19 L. Ed. 339); *Elizabeth* v. *American Nicholson Pavement Company*, 97 U. S. 137 (24 L. Ed. 1005); *Sessions* v. *Romadka*, 145 U. S. 29 (36 L. Ed. 609); *Hoyt* v. *Horne*, 145 U. S. 302 (36 L. Ed. 713). The converse is equally true. The patentee may bring the defendant within the letter of his claims, but if the latter has so far changed the principle of the device that the claims of the patent literally construed, have ceased to represent his actual invention, he is as little subject to be adjudged an infringer as one who has violated the letter of a statute has to be convicted, when he has done nothing in conflict with its spirit and intent. 'An infringement,' says Mr. Justice Grier in *Burr* v. *Duryee*, 68 U. S. 1 Wall. 531, 572 (17 L. Ed. 650, 658), 'involves substantial identity, whether that identity be described by the terms, "same principle," same "*modus operandi*," or any other. * * * The argument used to show infringement assumes that every combination of devices in a machine which is used to produce the same effect is necessarily an equivalent for any other combination used for the same purpose. This is a flagrant abuse of the term equivalent.'

"We have no desire to qualify the repeated expressions of this court to the effect that where the invention is functional, and the defendant's device differs from that of the patentee only in form, or in a rearrangement of the same elements of a combination, he would be adjudged an infringer, even if, in certain particulars, his device be an improvement upon that of the patentee. But, after all, even if the patent for a machine be a pioneer, the alleged infringer must have done something more than reach the same result. He must have reached it by substantially the same or similar means, or the rule that the function of a machine cannot be patented is of no

practical value. To say that the patentee of a pioneer invention for a new mechanism is entitled to every mechanical device which produces the same result is to hold, in other language, that he is entitled to patent his function. Mere variations of form may be disregarded, but the substance of the invention must be there. As was said in *Burr* v. *Duryee*, 68 U. S. 1 Wall. 531, 573 (17 L. Ed. 650, 659), an infringement 'is a copy of the thing described in the specification of the patentee, either without variation, or with such variations as are consistent with its being in substance the same thing. If the invention of the patentee be a machine, it will be infringed by a machine which incorporates in its structure and operation the substance of the invention; that is, by an arrangement to mechanism which performs the same services or produces the same effect in the same way, or substantially the same way.' 'That two machines produce the same effect will not justify the assertion that they are substantially the same, or that the devices used by one are therefore mere equivalents for those of the other.'"

For the above reasons, we submit that the Circuit Court of Appeals erred in applying the doctrine of equivalents in the present case. But even if it were true that the means, operation and result of Petitioner's device are sufficiently close to those of the patent in suit to invoke the doctrine of equivalents under some circumstances, that doctrine is not applicable here because of the cancellation by Walker of a claim specific to Petitioner's accused device.

"It is a rule of patent construction consistently observed that a claim in a patent as allowed must be read and interpreted with reference to claims that have

been cancelled or rejected and the claims allowed cannot by construction be read to cover what was thus eliminated from the patent. (Cases cited.) The patentee may not, by resort to the doctrine of equivalents, give to an allowed claim a scope which it might have had without the amendments, the cancellation of which amounts to a disclaimer. *Smith* v. *Magic City Kennel Club*, 282 U. S. 784, 790, 75 L. Ed. 707, 712, 51 S. Ct. 291; *Weber Electric Co.* v. *E. H. Freeman Electric Co., supra*, (256 U. S. 677, 678, 65 L. Ed. 1167, 1168, 41 S. Ct. 600); *I. T. S. Rubber Co.* v. *Essex Rubber Co., supra*, (272 U. S. 444, 71 L. Ed. 343, 47 S. Ct. 136). The injurious consequences to the public and to inventors and patent applicants if patentees were thus permitted to revive cancelled or rejected claims and restore them to their patents are manifest." (Case cited.)

Schriber-Schroth Co. v. *Cleveland Trust Co.*, 311 U. S. 211, 220, 221, 85 L. Ed. 132, 137.

A patentee who has cancelled claims on particular subject matter has dedicated all rights which he might have had therein to the public. The patentee is "estopped to claim the benefit of his rejected claim or such a construction of his amended claim as would be equivalent thereto." *I. T. S. Rubber Co.* v. *Essex Rubber Co.*, 272 U. S. 429, 444, 71 L. Ed. 335, 343.

" * * * the rule is a rule of law, not merely a procedural rule of the Patent Office; it is an adaptation for patent cases of the basic doctrine of *res judicata*, estopped by judgment. Whether the second proceeding is an interference, a reissue, a suit to obtain letters patent, or any other type of action, the first proceeding is *res judicata* on all claims that were made or could have been made therein."

—*Daniels* v. *Coe*, 116 Fed. (2d) 941, 943, U. S. Court of Appeals for the District of Columbia. (Opinion by Associate Justice Vinson.)

Usually the "file wrapper estoppel" arises where a patentee first presents broad claims but later cancels them and accepts narrow ones from the Patent Office. But in *Schriber-Schroth* v. *Cleveland Trust Co.*, 311 U. S. 211, the doctrine was extended to cover a situation where *broad* claims were *allowed* by the Patent Office *after* rejection and cancellation of *narrow* claims, the Court stating:

> "True, the rule is most frequently invoked when the original and cancelled claim is broader than that allowed, but the rule and the reason for it are the same if the cancelled or rejected claim be narrower. (Cases cited.)
>
> " * * * it does not appear why the patent office allowed the broad claims after rejecting the narrower ones. But in any case the patentee, having acquiesced in their rejection, is no longer free to gain the supposed advantage of the rejected claims by a construction of the allowed claims as equivalent to them."
>
> —311 U. S. 211, 221, 85 L. Ed. 132, 138.

Therefore, the fact that the claims here in suit are broader than those previously rejected by the Patent Office is of no significance. The facts are not different from those in the *Schriber-Schroth* v. *Cleveland Trust Co.* case in that respect. The only difference here lies in the fact that Walker filed two applications for patent instead of one. The proceedings, upon which we rely chiefly to show the proper construction of the claims in suit, took place in the co-

pending application rather than the one which matured into the patent in suit. Walker conceived of the electrical system with a filter at about the same time that he conceived of the mechanical tuning device of the patent in suit.* The second application (Exhibit "L" on the electrical system) was filed Sept. 18, 1937 (R. 954), only eleven days after the filing of the application on the mechanical system. This is simply a case where two devices are thought of for accomplishing a desired result, and two applications are filed instead of one showing both embodiments.

Co-pending applications on related subject matter are, in effect, one stage in a continuous effort to obtain patent rights. (See discussion in the opinion by Associate Justice Vinson in *Summerhays* v. *Coe*, 105 Fed. (2d) 73, U. S. Court of Appeals for the District of Columbia.)

While no case has been found where this Court has considered the effect of a patentee voluntarily dividing an invention and filing two applications, or the effect upon a patent of proceedings in a co-pending application, similar situations have arisen in the lower courts, and the established rules, as stated in 48 Corpus Juris 218 are:

> "Where it is in evidence from the record of the patent office that a certain construction was there contemplated, and that the patent would not otherwise have been granted, that construction will be

---

*"Q. When did you first conceive of the idea of using a filter in an amplifier circuit in a recording system which has a microphone recorder as shown in figure 5 of the drawing of application serial No. 164,534, offered as defendant's Exhibit L?

A. To the best of my knowledge that was about the time I started experimenting with acoustical tuning, which was during the early part of 1937." (Walker, R. 516, 517).

followed, and no objection can be made to the same construction on the ground that it is narrow, and will render the patent practically useless. But an interpretation by the patent authorities extending claims beyond their proper import is not binding on the public. * * *

"Where different applications by a patentee, and interference proceedings relating to the same subject matter are pending at the same time, all may be considered in determining the construction of the patent, as granted. * * *

"Where an inventor divides up his invention so as to present certain elements in different patents, he is thereby limited to a more strict and narrow construction than might have been otherwise necessary."

In *North American Chemical Co.* v. *Dexter*, 252 Fed. 148 (D.C. E.D. Wisc.), there was a situation similar to that in the present case. Three patents to Thoma and one to Arnold, all assigned to the plaintiff, had been pending in the Patent Office at the same time. The Court investigated all the proceedings in the Patent Office, saying:

"It is my judgment that the court is not only permitted, but is required, to consider the plaintiffs' claims, in view of the time and condition under which the four patents were brought out. They were practically concurrent and co-pending patents. Each one seeks to be contributory in a greater or less degree to the advance or change in the art which it is proposed to bring about. Whatever might have been the course to be pursued in interpreting or construing them, if they appear to be otherwise independent, the court is not at liberty, nor is it fair to the patentee, to ignore the express reference made in these several patent records to the pendency of the other patents

and the general purposes sought to be accomplished by the four patents as a whole. If the problem concerned the interpretation of land or other property grants, each containing references to the provisions or the purposes of the other, the court would not hesitate to fully refer to all of them for the purpose of ascertaining the true intent and the construction to be placed upon each, as well as upon all." 252 Fed. at 160, 161.

In *Tampax, Inc. v. Personal Products Corporation*, 123 Fed. (2d) 722 (C. C. A. 2), the patentee, Haas, had cancelled claims from a first filed application. At the same time that he cancelled the claims he filed a second application with an amended specification and attempted to recapture what he had abandoned in the first application. The claims, which issued in the second application, were held limited by the doctrine of file-wrapper estoppel and hence not infringed. The Court said:

"If Haas had secured the claim by the introduction of Figure Two and 'the second passage' into the first application, we cannot doubt that there would have been a 'file-wrapper estoppel.' *I. T. S. Rubber Co.* v. *Essex Rubber Co.*, 272 U. S. 429, 444, 47 S. Ct. 136, 71 L. Ed. 335; *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, 221, 61 S. Ct. 235, 85 L. Ed. 132. He would have failed to get a claim based upon such 'convolutions' as were inevitable by forcing a long strip into a short core; and in its place he would have secured a claim into which he introduced the element that the 'convolutions' must be regular zigzags. Obviously it made no difference that this limitation was incorporated into the claim only by references; and it also made no difference that the claim was itself

transferred from the earlier application to another, co-pending with it. The doctrine of 'file-wrapper estoppel' depends upon the fact that, when an applicant has accepted the rejection of a broad claim he may not later assert that another claim, deliberately restricted to secure its allowance, is its equivalent; and that argument is as cogent when the claim is transplanted into a new application as when it is amended in the original." 123 Fed. (2d) at 723.

The facts in the *Tampax* case are, of course, different from those in the case at bar, but the case illustrates the importance of considering all the proceedings in the Patent Office relevant to the issuance of claims. If only the file wrapper of the patent in suit had been considered, no estoppel could have been shown.

In *Dodge Needle Co.* v. *Jones,* 159 Fed. 715 (C. C. A. 3), where the facts were similar to those in the *Tampax* case, the Court said:

"* * * the admissions and statements of the applicant in the former case are not irrelevant to the issues now under consideration, and we are not to be asked to close our eyes to evidential facts upon a ground so slight as the one suggested.

* * * * * * * * * * *

"Whatever view we take as to the question, whether or not the application of August, 1901, was a continuation of the original application of November, 1899, it seems clear that, after the withdrawal of claims 4 and 5 of the new application, the invention covered thereby was abandoned, and needles with headed pins, as described therein, became public property, and cannot now be monopolized by the appellants." 159 Fed. at 722, 725.

In *Lewis Blind-Stitch Mach. Co.* v. *Arbetter Felling Machine Co.*, 208 Fed. 992, D.C. N.D. Illinois E.D., (affirmed 219 Fed. 557) the facts were quite similar to those in the case at bar. Soon after Lewis filed the application which matured into the patent in suit, he filed another application called the "seam-application." (See 208 Fed. 1000). Both parties sought to construe the patent in suit by reference to the co-pending application. Judge Sanborn said:

> "Ordinarily a patent is to be construed by its own contents, its file wrapper, and a consideration of what there was left previously undiscovered in the particular art. The patent is the measure of the grant; other applications not usually being material to its construction. But the rule of construction adopted respecting several deeds or contracts between the same parties, made about the same time, relating to the same subject-matter, and as parts of the same transactions, undoubtedly applies to patents and patent applications. All may be resorted to on an inquiry as to the meaning of any one. The seam-applications, interference, and Lewis' patent application, related to the same subject-matter, and were all pending during substantially the same period. Therefore all may be looked into to determine the proper construction of the Lewis patent." 208 Fed. at 1001.

In the present case, it must be presumed that the Examiner of Division 5, who handled the application which matured into the patent in suit, regarded the claims as limited to an acoustical device. That is all that is disclosed in the patent. The Examiner cited no art on electrical filters or electrical tuning. Had he regarded such

systems as within the scope of the claims, it would have been his duty to consult with the Examiner in Division 42. The result would have been a citation of art on electrical tuning and the rejection of the claims on the basis that no invention was involved in incorporating a filter in the Lehr and Wyatt electrical recording system, just as the Examiner in Division 42 rejected (R. 1002) claim 15 specific to the electrical system on that basis when the question was presented to him in the co-pending application Exhibit L (R. 953).

Throughout the prosecution in the Patent Office, both in the application which matured into the patent in suit and in the co-pending application Exhibit L, Walker denied any intention of obtaining broad protection. Extensive arguments and representations were made to the Patent Office that the revised claims containing the new phrases "pressure responsive device," "means for tuning," "means to accent," "interference eliminating means," "resonance means," "natural acoustical period of oscillation," etc., limited the claims to the structure shown in the drawing and described in the specification (R. 1476, 1477, 1532, 1533, 1534). It was argued repeatedly that the gun of the Batcheller patent could not be used (R. 1468, 1469, 1487, 1499, 1513).

We submit that the Circuit Court of Appeals erred in ignoring the proceedings in the Patent Office, in both the application [Exhibit T (R. 1415)] which matured into the patent in suit, and the co-pending application [Exhibit L (R. 953)]. We submit that these applications show that

Petitioner's device does not infringe the claims in suit, because it uses a gun instead of a pressure impulse chamber, because it uses a hot-wire microphone instead of a pressure responsive diaphragm, and because it uses ordinary electrical equipment to amplify and filter the desired signals instead of an acoustical resonator. Respondents sought, but the Patent Office refused to grant a patent on such a device, and the patent in suit should not be construed to cover it.

Conclusion

Respondents seek a monopoly on apparatus entirely different than that disclosed or intended to be covered by the patent grant. In consideration for disclosure of a pressure impulse chamber and a mechanical system for recording pressure pulses made with it, they seek, by broad, indefinite and functional claims, to prevent Petitioner from using a gun with an old and well-known electrical system adapted to record echoes. They ask the Court to ignore such limitations as were imposed in the claims during the prosecution of the application in the Patent Office and to ignore negotiations in the co-pending application seeking claims specific to an electrical recording system like that used by Petitioner.

The decisions of this Court in *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, and *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, preclude the attainment of such a result.

The claims are not drawn in accordance with the requirements of R. S. Sec. 4888 and should be declared invalid because they are functional and broader than the invention disclosed. If valid, they should be held not infringed by apparatus differing from that disclosed in the patent in means, operation and result. The proceedings in the Patent Office show that a device like Petitioner's was expressly excluded from the patent grant.

The decision of the Circuit Court of Appeals should be reversed.

Respectfully submitted,

EARL BABCOCK,
Duncan, Oklahoma;
HARRY C. ROBB,
Woodward Building,
Washington 5, D. C.,
Attorneys for Petitioner.

COPY

Office - Supreme Court, U. S.
FILED
OCT 18 1946
CHARLES ELMORE CROPLEY

IN THE

Supreme Court of the United States

(October Term, 1946)

No. 24.

Halliburton Oil Well Cementing Company, a Delaware corporation, *Petitioner*,

v.

Cranford W. Walker and Cranford P. Walker, D. A. Walker, Robert P. Miller and Milo C. Ketchum, doing business as Depthograph Company, a copartnership, *Respondents*.

REPLY BRIEF FOR HALLIBURTON OIL WELL CEMENTING COMPANY, PETITIONER, ON REARGUMENT BEFORE A FULL BENCH.

Earl Babcock,
Duncan, Oklahoma,

Harry C. Robb,
Woodward Building,
Washington 5, D. C.,
Attorneys for Petitioner.

Press of Byron S. Adams, Washington, D. C.

IN THE

Supreme Court of the United States

(October Term, 1946)

No. 24.

Halliburton Oil Well Cementing Company, a Delaware corporation, *Petitioner*,

v.

Cranford W. Walker and Cranford P. Walker, D. A. Walker, Robert P. Miller and Milo C. Ketchum, doing business as Depthograph Company, a copartnership, *Respondents*.

REPLY BRIEF FOR HALLIBURTON OIL WELL CEMENTING COMPANY, PETITIONER, ON REARGUMENT BEFORE A FULL BENCH.

In Respondents' Brief (pages 5 to 15), an agrument is made based upon the commercial success of the Depthograph Company in measuring fluid levels in oil wells. It is said that there was a long-felt want for the invention of the patent in suit and that previous attempts to solve the problem were failures.

Commercial success is not relevant to the question of whether or not the claims of the patent in suit meet with the statutory requirements, nor is it relevant to the question of file wrapper estoppel. "Long felt want" and "commercial success" are relevant only to the question of invention and even then they are not always considered. *Dow Chemical Co.* v. *Halliburton Oil Well Cementing Co.*, 324 U. S. 320, 89 L. Ed. 973; *McClain* v. *Ortmayer*, 141 U. S. 419, 35 L. Ed. 800; *Lovell Mfg. Co.* v. *Cary*, 147 U. S. 623, 37 L. Ed. 307; *Duer* v. *Corbin Cabinet Lock Co.*, 149 U. S. 216, 37 L. Ed. 707.

The statements in Respondents' brief as to commercial success are not correct. There was no long felt want. The prior attempts were successful (R. 258, 259). Respondents themselves were successful before the invention in suit was made. The alleged invention in suit was made March 6, 1937 (R. 196). Prior to that time a number of fluid level determinations were made commercially. [See list of wells tested in 1936, 1937 and 1938 (R. 1256, 1257).]

Walker went into this business after seeing the Lehr and Wyatt apparatus being run. (R. 154, 155, 514, 515).

Lehr and Wyatt were not using a recorder but their patent 2,047,974 (R. 1102), which is prior art, *discloses*, in Figure 2, a microphone, amplifier and recorder. Testimony in this record (R. 290-297, 416-418, 432, 433) shows conclusively that when Petitioner's experts built and operated an apparatus in accordance with Figure 2 of the Lehr and Wyatt patent, it worked successfully and recorded echoes from tubing collars as well as fluid level and other obstructions in a well.

Respondent Walker is not the first to devise means for recording tubing collar echoes. That is inherent in the structure of the prior Lehr and Wyatt patent. Walker is not entitled to a monopoly on the use of the Lehr and Wyatt apparatus for that purpose. In *General Electric Co.* v. *Jewel Incandescent Lamp Co.*, 326 U. S. 242, this Court said:

> "If A, without mentioning the element of strength patented a bulb which was extra strong, B could not obtain a patent on a bulb because of its strength, though he was the first to recognize that feature of it. That is the import of Ansonia Brass & Copper Co. v. Electric Supply Co., 144 U. S. 11, 36 L. Ed. 327. * * * The benefits of the 'potencies and values more important than the uses that were immediately apparent' belong to him who establishes priority of discovery. Radio Corp. of America v. Radio Engineering Laboratories, 293 U. S. 1, 14, 79 L. Ed. 163, 171."

In Respondents' brief, pages 22 to 24, it is argued that the statements in our brief, page 35, are "refuted" by Dr. Mackeown and by Petitioner's instruction manual. It is true that the instruction manual contains an incorrect statement as to the operation of a filter. This manual is not sworn testimony. That the statement in the manual is not correct was stated positively by Dr. Mackeown while he was on the stand (R. 462, 463) and also by Cornes (R. 317-321). Dr. Mackeown did not testify that a filter, *when used as petitioner uses it*, has a period of oscillation corresponding to the frequency of tubing collar echoes. The citation at the bottom of page 22 of Respondents' brief, to the record page 469, is misleading. Dr. Mackeown's answer to counsel's question is separated from the context.

On pages 457 to 468 of the record, Dr. Mackeown testified as to the possibility of *maladjusting* the amplifier-filter circuit of Petitioner's Echo-Meter so as to make it oscillate. Dr. Mackeown testified that this could be done, but that if it were done, the circuit would no longer operate as an amplifier-filter.

Then, on page 469 of the record, cited in Respondents' brief, the following testimony appears:

> "Q. And with the filter set at that same value that we have spoken of in the last few questions, wouldn't the filter then have a natural period of oscillation corresponding to the frequency of the tubing collar echoes?

A. Yes, it would.

The Court: What you mean is that it can be set so that it oscillates and records the tubing collar echoes?

A. Well, maybe I can explain. Let's think of a pendulum in a grandfather's clock. That pendulum is not oscillating, but it has a perfectly natural frequency of oscillation because of its length, and if it starts oscillating, it will oscillate with that frequency. I think what Mr. Mattingly asked in his last question: It is a pendulum not moving, but it has a natural frequency of oscillation because of the structure, and if it does oscillate it will oscillate at the natural frequency."

From this explanation by Dr. Mackeown, it is clear that the filter in Petitioner's circuit never oscillates. It could be made to oscillate, but then it would not be performing the intended function, and it would then not be a filter.

In Respondents' brief, pages 28 and 29, it is averred in italics that "the Patent Office * * * evidenced the intention of the Patent Office that the claims should extend to and cover the very type of apparatus which respondent in this case complains is an infringement of his claims."

There is no support whatever for this assertion. In petitioning the Patent Office to have the application which resulted in the patent in suit made "special", Walker filed an affidavit (R. 1519) and so did his counsel, Mr. Mattingly (R. 1520). Walker's affidavit stated:

> "Affiant further states that he has personally inspected the apparatus employed by the competitors, International Geophysics Inc., and that the same incorporates mechanism for producing pressure waves in wells, mechanism for recording the same, and mechanism for tuning instruments to accent the echoes from tubing collars or similar regularly spaced obstructions in the wells."

Mr. Mattingly's affidavit stated:

> "That, in addition thereto, affiant has carefully compared the evidence submitted to him including the photographs accompanying the said petition and, in

his opinion, the competitor, International Geophysics, Inc., is clearly infringing claims 26, 27 and 28 of this application."

Claim 26 (R. 1454) of the application which was said to be infringed read as follows:

> "In an apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure responsive device for receiving pressure impulses from the well, a means intercoupling said pressure responsive device with the well and having such effective length as to tune said pressure responsive device to one of the harmonics of echoes of said impulse received from the coupling collars of said tubing string, and means associated with said pressure responsive device for measuring the frequency of said tubing collar echoes and for counting the same and for measuring the lapse of time between the creation of said impulse and the arrival at the pressure responsive device of the echo of the impulse from said obstruction."

Since this claim 26 includes "means intercoupling said pressure responsive device with the well and having such effective length as to tune said pressure responsive device", these affidavits are to the effect that Walker's competitor, International Geophysics, Inc. was using an acoustical resonator of adjustable length.

We do not know whether International Geophysics, Inc. was using an acoustical tuned resonator or not. There is very little in the record about what International Geophysics, Inc. was using.

But these affidavits, far from apprising the Examiner in the Patent Office of the fact that Walker intended to assert this patent against one who was merely using an electrical filter, lulled the Examiner into a belief that the patent would be asserted only against one who was using a device "having such effective length as to tune". Nowhere

in the several applications which Walker filed in the Patent Office is there any mention whatever of the alleged equivalency of a *filter* and an acoustical resonator.

In Respondents' brief, pages 29 to 31, Walker's copending application (Exhibit L, R. 953) on the electrical recording system is discussed. Our entire argument as to claim 15 of that application and the admissions made by Walker as to it, is ignored.

Counsel discuss claim 35 which was presented to the Patent Office after the patent in suit had been granted and which was rejected on the patent in suit. This has nothing whatever to do with the question of file wrapper estoppel.

Petitioner introduces in evidence the file wrapper of the copending application (Exhibit L) to show that the Patent Office refused to grant Walker a patent on the use of a filter in the prior Lehr and Wyatt recording system and that Walker acquiesced in that action.

Respondent seeks to use this exhibit in lieu of testimony by experts on the question of interpretation of the claims in suit.

We submit that the only proper use of Exhibit L is in connection with Walker's admissions.

In connection with the two questions of law here involved, Respondents' brief sets up straw men which are then knocked down. Since other points of law are involved in *General Electric* v. *Wabash*, 304 U. S. 364, and in *Schriber-Schroth* v. *Cleveland Trust Co.*, 311 U. S. 211, than are relied upon by Petitioner, Respondents show that these other points are not applicable here and then argue that those cases are not controlling.

Petitioner is not asking this Court to overrule the decision in *Continental Paper Bag Co.* v. *Eastern Paper Bag Co.*, 210 U. S. 405, nor is it asking that a ruling be made condemning all claims which use the word "means" followed by a statement of function. Petitioner urges that the decision of this Court in *General Electric Co.* v. *Wabash*, citing with approval the decision of the Sixth Circuit Court

of Appeals in the case of *Davis Sewing Machine Co.* v. *New Departure Mfg. Co.*, 217 F. 775, sets forth the law applicable to the facts here and that the use of clauses which are purely functional in claims should be condemned where they are used purportedly to define the exact point of novelty. In other words, claims must distinguish from the prior art by a recitation of structure rather than function, if they are to be valid. This has always been the law. It is the law of *Continental Paper Bag Co.* v. *Eastern Paper Bag Co.*, the decision there being that the claims defined the exact point of novelty by a recitation of structure and that the functional clauses in the claim were directed to other than the exact points of novelty.

As to the second question of law involved here, Petitioner is not seeking to have a broad patent limited merely because the patentee filed a second application. Petitioner is seeking to have a patent construed in the light of admissions made in a copending case following a rejection *on art which is prior to both*. When Walker cancelled claim 15 of the copending application and admitted (R. 1015) that no invention was involved in placing a filter in the prior Lehr and Wyatt system, he dedicated to the public such rights as he might have had therein. Under the law, nothing that he subsequently did, and nothing that the Examiner subsequently said, can revoke that dedication. Petitioner, or any other member of the public, has as much right to use a filter in the Lehr and Wyatt system as Walker has. This is entirely different from a case where, in an application on an improvement, a rejection is made on the applicant's own prior patent and an assertion is made that the earlier patent is broad. One case is an admission that the public has certain rights. The other is only a contention that the inventor's rights are covered by another patent.

We submit that the claims in suit should be declared invalid under the doctrine of *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, or, if this doctrine does not apply, that the claims be declared not infringed because of

the estoppel arising from the admissions made in the Patent Office, which under the doctrine of *Schriber-Schroth v. Cleveland Trust Co.*, 311 U. S. 211, bar the application of the doctrine of equivalents.

Respectfully submitted,

EARL BABCOCK,
Duncan, Oklahoma,

HARRY C. ROBB,
Woodward Building,
Washington 5, D. C.,
Attorneys for Petitioner.

FILE COPY

Office - Supreme Court, U. S.
FILED
AUG 31 1945
CHARLES ELMORE CROPLEY
CLERK

IN THE

Supreme Court of the United States

OCTOBER TERM, 1945.

No. [redacted] 24

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware Corporation,

Petitioner,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as DEPTHOGRAPH COMPANY, a copartnership,

Respondents.

BRIEF FOR RESPONDENTS IN OPPOSITION TO PETITION FOR WRIT OF CERTIORARI.

HAROLD W. MATTINGLY,
621 South Hope Street, Los Angeles 14, California,
Attorney for Respondents.

Parker & Company, Law Printers, Los Angeles. Phone TR. 5206.

TOPICAL INDEX.

	PAGE
Petitionet's Ground 1	4
Petitioner's Ground 2	8
Petitioner's Ground 3	12

TABLE OF AUTHORITIES CITED.

CASES.	PAGE
Buono, et al. v. Yankee Maid Dress Corporation, 77 F. (2d) 274, 277	6
General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364	3, 4, 6
General Talking Pictures v. Western Electric Co., Inc., 304 U. S. 175	3
Keller v. Adams Campbell Co., 264 U. S. 314	3
Layne & Bowler Corp. v. Western Well Works, Inc., 261 U. S. 387	3
Schriber-Schroth Co. v. Cleveland Trust Co., 311 U. S. 211	9, 11

IN THE

Supreme Court of the United States

OCTOBER TERM, 1945.

No. 290.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware Corporation,

Petitioner,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as DEPTHOGRAPH COMPANY, a copartnership,

Respondents.

BRIEF FOR RESPONDENTS IN OPPOSITION TO PETITION FOR WRIT OF CERTIORARI.

To the Honorable Chief Justice and Associate Justices of the Supreme Court of the United States:

This case is but an ordinary patent infringement suit wherein the defendant Halliburton Oil Well Cementing Company has been and is now making and using instruments for the surveying of oil wells to determine the height of the column of fluid in an oil well bore as a service for pay to various oil companies, such instruments embodying plaintiffs' patented inventions and plaintiffs brought this suit for infringement.

The District Court, after hearing and receiving the evidence, held that plaintiffs' patent No. 2,156,519 was valid and infringed as to the claims in issue and entered appropriate findings of fact and conclusions of law. [R. 27-32.]

Defendant appealed to the Circuit Court of Appeals for the Ninth Circuit, which Court after hearing affirmed the decision of the District Court as to both infringement and validity. [R. 1594-1604.]

Defendant thereupon petitioned the Circuit Court of Appeals for the Ninth Circuit for rehearing, setting forth in detail the two questions which it now presents to this Court upon its petition for a Writ of Certiorari. To this petition, respondents filed a reply.

Upon a full consideration of the petition for rehearing and the grounds set forth, the Ninth Circuit Court of Appeals entered an order directing filing of opinions on petition for rehearing and denying petition. [R. 1613-1616.]

There is no conflict of decision with respect to plaintiffs' patent between two Circuit Courts of Appeals, nor does this case involve any principle, the settlement of which is of importance to the public interest.

Apparently the defendant, having presented both in the District Court and in the Circuit Court of Appeals for the Ninth Circuit, its best arguments, its best defenses and its best theories, to be met only with failure, now seeks to have this Court review the same arguments, defenses and theories in the hope that this Court will disagree with the District Court and the Circuit Court of Appeals.

It is contended therefore by respondents that defendant presents no case to this Court which would warrant the grant of a Writ of Certiorari.

Petitioner urges that despite the fact that there is no conflict of decision in the several Circuit Courts with respect to plaintiffs' patent, an exception should be made in this case to the general rule of this Court as announced in *Layne & Bowler Corp. v. Western Well Works, Inc.*, 261 U. S. 387; *Keller v. Adams Campbell Co.*, 264 U. S. 314; *General Talking Pictures v. Western Electric Co., Inc.*, 304 U. S. 175, for the purported reasons:

(1) That petitioner feels that the ruling of the Circuit Court of Appeals for the Ninth Circuit is in conflict with the decision of this Court in *General Electric Co. v. Wabash Appliance Corp.*, 304 U. S. 364;

(2) That petitioner feels that a question of great public importance has been raised but not decided by petitioner's fantastic theory that because the Patent Office held that plaintiffs' patentee was not entitled to a second patent covering only a mechanical equivalent of the subject matter disclosed and claimed in the patent in suit, then the claims of the patent in suit should be construed so narrowly as not to include what the Patent Office held to be a mechanical equivalent within the scope of the claims of the patent in suit; and

(3) That plaintiffs fear that because no other suits have been started in other circuits on plaintiffs' patent, conflict between Circuit Courts of Appeals is improbable.

In the following, the foregoing grounds will be discussed in the order presented:

Petitioner's Ground 1.

As to petitioner's first ground, petitioner is seeking a ruling by this Court that in a claim for a combination of elements cooperating together to perform a single new and useful result the patentee must recite every element of the combination in specific and limited terms whereas it is fundamental patent law that where a patentee is the first to combine together a new combination of elements or pieces of apparatus to achieve a new result he is entitled to broad claims upon that combination of elements and may recite the elements as broadly as the prior art will permit.

In presenting its theory petitioner seeks to broaden the ruling of this Court in *General Electric Co. v. Wabash Appliance Corp.*, 304 U. S. 364, to cover a situation which was not present in that case.

In the *General Electric Co. v. Wabash Appliance Corp.* case the question presented to this Court was that of determining whether or not a claim to an article of manufacture constituting a single element was sufficiently definite to teach the art how to practice that invention when the language of the claim was so vague as to fail to act as a guide to those who might desire to practice the patented invention. This Court justly held that the patentee in that case had not complied with the requirement of the Patent Statutes to specifically point out the novelty sought to be covered by the patent.

In the instant case the situation is entirely different in that the patentee in the patent in suit discloses for the

first time the combination of three elements excellently set forth and discussed by Judge Denman in his concurring opinion on the denial of the petition for rehearing by the Circuit Court of Appeals for the Ninth Circuit as elements "A," "B" and "C." [R. 1614-1616.]

In the instant case, although the prior art may have shown the combination of elements B and C (and for the purposes of this argument it may be assumed that the prior art did show the combination of those two elements), the prior art did not show the combination therewith of the third element D.

Petitioner bases its entire theory as to the first ground of this petition upon the assertion that the expression "means," followed by a statement of the function such means is to perform in the combination, is fatally indefinite. That this theory is incorrect is obvious when the particular invention under consideration is analyzed.

The patentee Walker discovered that by adding element D into the combination with elements B and C a useful and successful device could be made which would accomplish the result which the prior art had sought to accomplish but had failed to achieve.

If petitioner's theory is adopted, then any patentee in attempting to claim a combination of elements or pieces of apparatus would be required to recite each of the elements in specific detail and the claim which would be awarded to him could be construed only to cover specifically the one embodiment of the invention which he il-

lustrates and describes in detail in the specification of his patent.

That this was not the intent of this Court in its decision in the *General Electric Co. v. Wabash Appliance Corp.* case is obvious from a reading of the opinion in that case and it is further obvious that this Court had no intention of denying reasonably broad scope to the claims of a patent which defines not only the difference between success and failure but a real and material advance in the art.

It is submitted that the carefully considered and carefully worded opinions of the Circuit Court of Appeals for the Ninth Circuit, both the original opinion written by Judge Healy and the opinion on the petition for rehearing written by Judge Healy, as well as the concurring opinion written by Judge Denman, demonstrate that the Circuit Court of Appeals for the Ninth Circuit was not only fully cognizant of the import of the ruling of this Court in the *General Electric Co. v. Wabash Appliance Corp.* case but distinguished the facts of the instant case from those of the *General Electric Co. v. Wabash Appliance Corp.* case in accordance with established principles of patent law.

In the instant case the facts presented are identical with those considered by Judge Hand in *Buono, et al. v. Yankee Maid Dress Corporation*, 77 F. (2d) 274, 277, in which the Court stated:

> "The only debatable matter is of the language of the claims themselves; it is the old question of how

far a claim may safely be cast in terms of function. * * * The other elements of claim 6 except a single one are in mechanical terms referable to the disclosure, and are clearly not functional. The exception is, 'operating means connected to said eccentric device and turning said pivoted device at predetermined intervals.' This too is readily enough identified by the disclosure, and though it does speak in terms of function that is inevitable to some degree, if the claim is to have any generality whatever. The very test of equivalency is in terms of function, 'the same result by the same means'; *and it is only by recourse to that standard that a patentee can pass beyond the very details of his disclosure.* Some such latitude being necessary, it is only a question of how far the functional element is anchored in the disclosure, and how far it floats as a vague threat to the art. That is a question of degree, and admits of no general solution, for the mere use of the word 'means' does not condemn a claim. Tokheim Oil Tank & Pump Co. v. Dean, 73 F. (2d) 32, 35, 36 (C. C. A. 7); Heidbrink v. McKesson, 290 F. 665, 668 (C. C. A. 6). In the case at bar the phrase was justified because the invention did not reside in the mechanical train connecting the eccentric with the table, but in a train which should tilt it at intervals longer than the oscillations of the rib. The details not being important, the general notion so embodied the inventors might protect." (Emphasis added.)

Therefore, as to Ground 1, petitioner has presented no valid reason for the grant of a Writ of Certiorari.

Petitioner's Ground 2.

To properly expose the fallacy of the theory upon which petitioner bases its second ground for its petition, it is only necessary to point out that the patent in suit was the first patent in the art to which it relates to disclose the combination of the three elements set forth by Judge Denman in his opinion. [R. 1614-1616.] To illustrate and specifically describe one embodiment of the invention, the patentee illustrated and described a "mechanical" structure in the sense that the structures illustrated and described were not electrical devices. The claims which were presented in the patent in suit and which were allowed and which are the claims in suit were couched in broad language sufficient to include both the specific mechanical devices illustrated and described in the patent and "equivalents" thereof. Subsequent to the filing of the application for the patent in suit, the patentee filed a second application in which the specific embodiment of the invention is illustrated and described as including electrical devices.

Upon examination of the second application, the Patent Office, then having access to the patentee's prior patent (the patent in suit), cited the patent in suit and rejected claims to the electrical version of the device *upon the ground that the electrical apparatus disclosed in the second application was only the mechanical equivalent of the invention upon which the patentee had already been given a patent and which was included in the scope of the*

claims which had been granted in the earlier patent (the patent in suit).

Petitioner seeks to distort the ruling of this Court in *Schriber-Schroth Co. v. Cleveland Trust Co.*, 311 U. S. 211, to reach the absurd conclusion that a pioneer patentee, having obtained a broad claim upon an invention, one embodiment of which is illustrated and described in the patent, dares not file subsequent applications upon what he may consider are improvements over the specific disclosure in the first patent for fear that a rejection of the claims in the improvement patent will require the courts to limit the claims of his first patent to the specific embodiment of the invention illustrated and described therein and would prevent the construction of the claims in the first patent broadly enough to cover what the Patent Office might hold to be a mechanical equivalent thereof disclosed in the second application for patent.

The facts of the *Schriber-Schroth Co. v. Cleveland Trust Co.* case were that in a single patent application the patentee presented claims to a part of his invention and upon rejection canceled those claims *in order that that patent could issue*, and then the patentee sought at a later date to have others of the claims obtained in that patent so broadly construed as to cover the very subject matter which he canceled in order to obtain his patent.

In effect, in the *Schriber-Schroth* case the Court was presented with a contract, during the negotiations for which (the proceedings in the Patent Office) attempt was made to include material and upon rejection such mate-

rial was canceled in order that the contract might be completed. Then at a later date the patentee seeks to alter the terms of that contract to include the material he once sought to have in that contract but subsequently deliberately canceled therefrom.

In the instant case the patentee applied for and obtained a pioneer patent upon the combination and, in so doing, carefully drafted the claims so as to include not only the specific mechanical embodiment of his invention but "equivalents thereof." In a later attempt to obtain a second patent upon electrical apparatus for accomplishing the same result, the Patent Office held that the broad *electrical claims* defined only the mechanical equivalent of the subject matter upon which the patentee had already been granted broad claims capable of covering the electrical apparatus.

To adopt petitioner's theory would greatly injure the progress of science and the arts since once a patentee had disclosed one embodiment of his invention and obtained a patent thereon he would be discouraged from daring to disclose other embodiments and improvements for fear that by so doing he would destroy the protection he had already been granted.

This fallacious theory was advanced by petitioner to the Circuit Court of Appeals for the Ninth Circuit and the absurdity of the theory was undoubtedly the reason the Circuit Court did not even deign to refer to it in its opinion on the petition for rehearing.

The facts in the instant case are clearly distinguishable from the *Schriber-Schroth Co. v. Cleveland Trust Co.* case and are so admitted to be by petitioner on page 13 of its petition to this Court, wherein it is stated:

> "In many other cases, this Court has applied the doctrine of file wrapper estoppel, but we have been able to find no case in which the facts are exactly the same as those in the case at bar.
>
> "Walker could have filed one application for patent covering the two systems he had conceived. Instead, he filed two applications, one on the mechanical system and one on the electrical. Had both ideas been presented in one application and those on the electrical system been rejected on the prior art and cancelled, the facts would be the same as in the above cited cases."

What petitioner fails to say is that in the instant case *there was no prior art upon which the electrical claims could be rejected* except Walker's own patent in suit.

It is therefore submitted that, as to Ground 2, no principle of patent law is presented in this case which would warrant the grant of a Writ of Certiorari by this Court.

Petitioner's Ground 3.

In support of its Ground 3, petitioner urges that petitioner and respondents are the only concerns furnishing sonic depth measuring apparatus to owners and operators of oil wells and that for this reason conflict between the Circuit Courts as to the patent in suit is improbable.

Petitioner refutes its own argument by pointing out that, in addition to petitioner and respondents, at least one other company, the Gulf Oil Company, has made and used a device of the character involved in this litigation and hence constitutes another competitor against which suit will probably be brought under the patent in suit in another circuit.

It is submitted that the mere fact that respondents have not as yet instituted other suits in other circuits is not sufficient ground for this Court making an exception in this case to its general rule of refusing to grant a Writ of Certiorari where no conflict of opinion exists.

Respectfully submitted,

HAROLD W. MATTINGLY,
Attorney for Respondents.

Los Angeles, California,
August 21, 1945.

FILE COPY

Office - Supreme Court, U. S.
FILED
JAN 2 1946
CHARLES ELMORE CROPLEY

IN THE

Supreme Court of the United States

OCTOBER TERM, 1945

No. [redacted] 24

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Petitioner,

vs.

CRANFORD P. WALKER, and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Respondents.

BRIEF FOR CRANFORD P. WALKER, et al., RESPONDENTS.

HAROLD W. MATTINGLY,
920 Pacific Finance Building, Los Angeles 14,
Attorney for Respondents.

SUBJECT INDEX.

	PAGE
Questions presented	1
Statement of the case	4
The invention	4
The claims in suit	9
Summary of argument	13
Argument	14
Argument as to Question No. 1	14
Conclusion as to Question No. 1	30
Argument as to Question No. 2	30
Conclusion as to Question No. 2	36
Conclusion	37

TABLE OF AUTHORITIES CITED.

CASES.

PAGE

Apex Electrical Mfg. Co. v. Maytag Co., et al., 122 F. (2d) 182 26

Buono et al. v. Yankee Maid Dress Corporation, 77 F. (2d) 274 26

Continental Paper Bag Company v. Eastern Paper Bag Company, 210 U. S. 405, 28 S. Ct. 748.....13, 14, 21, 23, 27, 37

Davis Sewing Machine Co. v. New Departure Manufacturing Co., 217 Fed. 775.....16, 23

General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364.....1, 13, 14, 16, 18, 19, 21, 28, 29, 30, 37

General Talking Pictures Co. v. Western Electric Company, Inc., 304 U. S. 175..... 3

Gilchrist Co. et al. v. KarLac Co., et al., 29 F. (2d) 153..... 26

Schriber-Schroth Co. v. Cleveland Trust Co., 311 U. S. 211.....2, 14, 30, 31, 35

STATUTES.

United States Revised Statutes, Sec. 4888..... 2

IN THE

Supreme Court of the United States

OCTOBER TERM, 1945

No. 290.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Petitioner,

vs.

CRANFORD P. WALKER, and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Respondents.

BRIEF FOR CRANFORD P. WALKER, et al., RESPONDENTS.

QUESTIONS PRESENTED.

The petition for writ of certiorari in this case presents to the Court only two questions to be determined:

(1) Is the doctrine of the case of *General Electric Co. v. Wabash Appliance Corp.*, 304 U. S. 364, condemning the use of indefinite and functional language at the exact point of novelty in a claim of a patent, applicable to a claim on a combination of elements, or should the doctrine be limited as held [R. 1614, 1616] by the Ninth Circuit Court of Appeals, to a claim on a "single element" or "specific product"?; and

(2) Is the doctrine of the case of *Schriber-Schroth Co. v. Cleveland Trust Co.*, 311 U. S. 211, precluding the giving of a claim of a patent such scope as will include within its terms subject matter rejected and cancelled while the application for patent was pending, applicable to a situation where an inventor files two applications on different species of his invention, the rejection and cancellation taking place in one and the claim in suit issuing in the other?

The real question petitioner is attempting to present to this Court with reference to question (1) is:

> Where an inventor has invented a new machine comprising a novel combination of elements or instrumentalities coacting with each other to produce a new result, and has in the specification and drawing of his patent disclosed one complete embodiment of such combination of elements, has he complied with the requirements of Sec. 4888 of the Revised Statutes *when in his claims he recites each element in terms of "means" followed by a statement of the function which such element performs in coaction with the other elements to achieve the new result?*

As to question (2), the real question which is presented to this Court is:

> Where an inventor in a patent describes and illustrates one embodiment of his invention with sufficient paticularity to satisfy the requirements of Sec. 4888 of the Revised Statutes and has purposely presented claims drawn in language broad enough to read not only upon that one specific embodiment *but also upon equivalents of that one embodiment*, are such claims to be so limitedly construed as to exclude from their

scope an equivalent of the embodiment disclosed in the patent merely because in a later application the Patent Office refused claims to such equivalent, and particularly where such refusal was based on the sole ground that the claims defined no more than the equivalent of the structure disclosed in the patent?

In Petitioner's brief these two questions are confused with arguments directed to questions of patentability over the prior art, anticipation of the claims by the prior art and arguments relating to whether or not the specific structure employed by Petitioner is or is not an infringement of the claims. All arguments except those directed specifically to the two questions raised by the petition for certiorari are immaterial to the decision of this case and such arguments presented in the Petitioner's brief must be disregarded. *General Talking Pictures Co. v. Western Electric Company, Inc.*, 304 U. S. 175.

Therefore, in this brief no attempt will be made to discuss the question of novelty of the patented invention over the prior patents or the question as to whether or not the specific structure employed by Petitioner constitutes an infringement of the claims of the patent in suit.

These latter issues were fully considered and were decided in both the District Court for the Southern District of California and by the Ninth Circuit Court of Appeals, and in accordance with established rules in the Supreme Court of the United States, the concurrent decisions of the lower courts on these questions will not be reviewed where a petition for writ of certiorari presents only specific questions which do not involve these issues. *General Talking Pictures Co. v. Western Electric Company, Inc., supra.*

STATEMENT OF THE CASE.

As stated in the brief of Halliburton Oil Well Cementing Company, Petitioner in this cause, this is a suit for patent infringement based upon the claim by Respondents, Cranford P. Walker, and Cranford P. Walker, D. A. Walker, Robert P. Miller and Milo C. Ketchum, doing business as Depthograph Company, a copartnership, that certain apparatus known as the "Echometer" used by Petitioner, Halliburton Oil Well Cementing Company, constitutes an infringement of Claims 1, 13, 14, 15 and 17 of United States Letters Patent No. 2,156,519, issued to Cranford P. Walker and under which the remaining Respondents are licensed.

The Invention:

Briefly, the invention described and claimed in the Letters Patent in suit relates to an apparatus which may be employed for the purpose of accurately determining how far up in an oil well bore the oil from the surrounding oil bearing formations extends while a pumping apparatus is in the well removing oil therefrom.

To more readily appreciate the problems presented to the inventor, Walker, and the manner in which these problems were solved by the structure disclosed and claimed in the Letters Patent in suit, it must be remembered that an oil well comprises essentially a well bore extending from the ground surface down to an underground oil pool, permitting the oil in the oil bearing sands far beneath the ground surface to enter the well bore, and from which the oil is pumped to the ground surface by means of mechanical pumping devices which are located within the well bore and usually at some depth

therein closely adjacent the point at which the well bore taps the oil pool. The oil in the formation is usually under considerable pressure, either due to the pressure of gases which have been trapped above the oil or due to the pressure effect of water in formations above the oil bearing sands, or both, so that the pressure exerted upon the oil tends to force the oil from the sands into the well bore and upwardly therein to some level considerably higher than the level of the point of entry of the oil into the well bore. In many oil wells the amount of pressure exerted on the oil within the oil bearing formation is sufficient to cause the oil to rise through the well bore completely to the ground surface as a "flowing" well, out of which oil flows without the aid of mechanical pumps or other apparatus for elevating the oil. In other wells, either due to lack of sufficient initial gas and water pressure exerted upon the oil in the oil bearing formations or due to the depletion of such pressure as the well continues to produce oil, the oil fails to flow to the ground surface, and mechanical pumps must be inserted into the well bore to elevate the oil to the ground surface, such pumps being usually suspended upon a string of pipe known as "tubing" comprising a number of lengths of pieces of pipe interconnected by means of couplings or tubing collars.

It has long been known in the oil industry that in wells employing mechanical pumps the natural pressures in the formation will cause the oil to rise in the well bore to some height above the point of entry of the oil into the well bore, and it has also been long appreciated that if the "fluid level" or location of the upper surface of the column of oil within the well bore were known, the pump-

ing apparatus to be employed in any particular well could be most efficiently selected and operated.

When a mechanical pump is employed in the well, it should remove the oil at some rate proportional to the rate at which the oil will flow under natural pressure from the formation, with the result that if the pump is operating with a high degree of efficiency the height of the fluid column in the well will be at a lower level than if the pump is operating at a lesser degree of efficiency and fails to remove the oil as fast as the oil can flow into the well from the formation.

It has long been known in the oil producing industry that if accurate information could be obtained as to the height of the column of fluid in the well while the pump in that particular well was operating to remove oil from the well, such information would be of great value in determining whether or not the pumping apparatus should be changed or whether or not the apparatus then located in the well should be operated at a different speed or at a different length of stroke in order to more efficiently produce oil from the well. Many attempts [R. 66] had been made to locate the fluid levels in such wells, most of which had required the removing of the pumping apparatus from the well, with the result that the fluid level indication which was so achieved did not truly represent the height of the fluid column in the well when the pump was actually operating.

Attempts had been made prior to the invention of Mr. Walker to utilize the principle of sound or acoustical wave reflections from the surface of the fluid column for the purpose of determining how far up in the well such column extended, one of such attempts being illustrated in

the Lehr and Wyatt patent No. 2,047,974 [R. 1101] wherein a quantity of gas under pressure was discharged into the space between the well casing and the tubing at the ground surface, the charge of gas creating a pressure impulse or acoustical wave which would travel down the well and be reflected back to the ground surface from the surface of the column of fluid standing in the well, and a receiving and recording apparatus located at the ground surface was adapted to be actuated by changes in gas pressure within the well casing resulting from the arrival of the echo or reflection of the wave from the fluid surface and so record the initiation of the impulse and later the reception at the ground surface of the reflected echo from the fluid surface.

This apparatus was similar to an apparatus which had been illustrated many years earlier in the prior patent to Batcheller No. 602,422 [R. 1065-1072], in which, in an effort to locate an obstruction in pneumatic tubes, a gun was fired into the tube and a receiving and recording apparatus was employed to receive and record the initial impulse created by the gun and the echo returning at some later time from the obstruction. In both of these previous methods the determination of the distance between the location of the obstruction and the recording apparatus (the distance between the fluid surface and the ground surface) was calculated under the fundamental theories of the speed of sound, namely, that sound would travel a given distance per second and that by measuring the number of seconds or the time interval between the initiation of the impulse and the reception of the echo the distance represented thereby could be mathematically determined.

Lehr and Wyatt discovered, as is explained in their patent, that the speed of sound or the acoustical wave created thereby was not uniform in all wells since the gaseous content and the temperature conditions existing in different wells varied so much that no one formula for the calculation of the relation between the time interval between the initiation of the impulse and the reception at the ground surface of the echo could be used for all wells and, in order to overcome this obstacle to the accuracy of their method and apparatus, they devised a corrective formula which attempted to calculate the speed of sound in any particular well. However, even with the use of the corrective formula, Lehr and Wyatt were unsuccessful in obtaining any accuracy of measurement of the distance between the ground surface and the fluid surface in a well [R. 118].

Mr. Walker [R. 154-158], with a license under the Lehr and Wyatt invention, attempted to commercialize the same and discovered that by securing registrations of echoes from a number of adjacent tubing collars in any particular well, as by recording upon a record chart the successive echoes from a series of successive tubing collars, the chart became self-calibrating for the particular well under test. In other words, the distance occupied by a series of adjacent tubing collar echoes would show the speed of the sound or acoustical wave in that particular well and would act as a measure to determine what was represented by the distance along the chart between the peaks *b* and *d* representing, respectively, the original impulse and the echo from the fluid surface. [See Walker patent 2,156,519, R. 588.]

The patent in suit therefore is directed to the combination of mechanical elements by which the Lehr and

Wyatt previous structure could be made to *successfully* and accurately make a record which could be translated into terms of distance between the ground surface and the location of the fluid surface in the well. In other words, Mr. Walker took the previous Lehr and Wyatt combination of two elements, namely: (a) a pressure impulse producing mechanism (the impulse chamber and quick opening valve) [see Lehr, *et al.* patent No. 2,047,-974, R. 1102-1105], and (b) the recording apparatus (microphone 15, recorder 16 and amplifier 18) *and added a third element, namely, (c) a means for accenting the tubing collar echoes and suppressing undesired noises.* By so doing, Walker converted the Lehr and Wyatt apparatus, which was a failure [R. 156-169], into a successful apparatus for accurately recording the location of fluid levels [R. 87].

The Claims in Suit:

The claims in suit recite this three-element combination discussed above as follows:

> Claim 1: In an apparatus for determining the location of an obstruction in a well having therein a string of assembled tubing sections interconnected with each other by coupling collars,
>
> (a) means communicating with said well for creating a pressure impulse in said well,
>
> (b) echo receiving means including a pressure responsive device exposed to said well for receiving pressure impulses from the well and for

measuring the lapse of time between the creation of the impulse and the arrival at said receiving means of the echo from said obstruction, and

(c) *means associated with said pressure responsive device for tuning said receiving means to the frequency of echoes from the tubing collars of said tubing sections to clearly distinguish the echoes from said couplings from each other.*

Claim 13: In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings,

(a) means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from the couplings and other obstructions in said well,

(b) echo receiving and registering means coupled to said well to expose said receiving and registering means to pressure variations produced in said well by echoes from said obstructions,

(c) *and means associated with said receiving and registering means to accent the registration of tubing coupling echoes.*

Claim 14: In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings,

(a) means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from couplings and other obstructions in said well,

(b) pressure responsive echo receiving and registering means coupled to said well to expose said receiving and registering means to pressure variations in said well produced by echoes from said obstructions, and

(c) *interference eliminating means associated with said receiving and registering means for limiting the response of said receiving and registering means to the registration of echoes from actual obstructions in the well whereby the registered echoes of the tubing couplings may be readily distinguished from each other and from the echoes from other actual obstructions in the well.*

Claim 15: In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings,

(a) means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from the couplings and other obstructions in said well,

(b) pressure responsive echo receiving and registering means coupled to said well to ex-

pose said receiving and registering means to the pressure variations produced in said well by echoes from said obstructions, and

(c) *resonance means associated with said receiving and registering means to produce therein a natural acoustical period of oscillation so related to the frequency of the echoes from the tubing couplings as to accent the registration of the tubing coupling echoes.*

Claim 17: In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings,

(a) means communicating with said well for creating therein a pressure impulse to produce echoes of said impulse from the couplings and other obstructions in said well,

(b) pressure responsive echo receiving and registering means having

(c) *a natural frequency of oscillation so related to the frequency of the echoes from said tubing couplings as to accent the registration of said echoes,* and

(d) means interconnecting said receiving and registering means to said well to expose said receiving and registering means to pressure variations in said well.

SUMMARY OF ARGUMENT.

1. Where an invention resides in a novel combination of a plurality of apparatus elements combined in such a way that a new result is achieved, the requirements of Sec. 4888 of the Revised Statutes are fully met by reciting each apparatus element as "means" followed by the necessary limiting statement of the function that the "means" is to perform in coaction with the remaining elements, as established in the doctrines stated in *Continental Paper Bag Company v. Eastern Paper Bag Company*, 210 U. S. 405, 28 S. Ct. 748, and subsequent cases citing the same.

2. Where the specification describes only one embodiment of the invention, the only way in which the inventor may obtain any coverage of equivalents of that one embodiment is to define the invention in the claims as a combination of different "means" with a statement of the function each "means" performs in coaction with the other "means" to produce the new result. Otherwise, the claims would have to recite the specific details of the particular embodiment disclosed, which would evidence that it was the intention of the patentee to limit his protection to the specific embodiment described and illustrated.

3. The doctrine of *General Electric Co. v. Wabash Appliance Corp.*, 304 U. S. 364 does not apply to the instant case because the facts in the *General Electric Co.* case were that neither the claims nor the specification contained a sufficient teaching as to how to practice the alleged invention and the claim in that case was a "single means" claim wherein the criticized functional statement was the only attempt at a definition of the *entire invention*, whereas in the instant case the facts are (a) that the teaching of the specification is clear and distinct, and (b)

the claims are combination claims wherein the terms of the claims clearly and distinctly define what is new and protected by them.

4. The doctrine of the *Continental Paper Bag Co. v. Eastern Paper Bag Co.*, 210 U. S. 405 applies to the instant case and to hold otherwise requires this Court to overrule that case.

5. The facts of the instant case are so different from those in the case of *Schriber-Schroth Co. v. Cleveland Trust Co.*, 311 U. S. 211, that the doctrine of that case does not apply here.

6. Patentee's acquiescence, in a later application, that electrical apparatus was the equivalent of the mechanical apparatus disclosed in the patent in suit does not limit the scope of the claims of the patent in suit to exclude electrical equivalents thereof.

ARGUMENT.

Argument as to Question No. 1:

It is the position of respondents as to question No. 1 that the facts of the instant case clearly and definitely distinguish this case from the *General Electric v. Wabash* case and that in that case the Supreme Court did not intend to overrule the principles and doctrines which it had previously laid down in *Continental Paper Bag Co. v. Eastern Paper Bag Co.*, 210 U. S. 405 with reference to claims to a combination of elements.

In the instant case the Ninth Circuit Court of Appeals twice considered the facts of the present case and compared them with the facts and the decision of the *General Electric Co. v. Wabash Appliance Corp.* case and twice found that the two cases were clearly distinguishable.

At the original hearing before the Ninth Circuit Court of Appeals, Petitioner urged that the claims in suit were indefinite and functional at the point of novelty in that the definition of the new element which had been added to the previously unsuccessful two-element combination disclosed in the Lehr and Wyatt patent merely recited this new element as a "means" followed by the statement of the function the new element was to perform in combination with the two old elements of the combination previously disclosed by Lehr and Wyatt. The original decision of the Ninth Circuit Court of Appeals states [R. 1599-1600]:

> "Walker made a very substantial improvement over Lehr and Wyatt, notwithstanding it is conceded that both his recorder and his amplifier, considered by themselves, are old in the art. We think the patentee displayed a measure of inventive genius entitling him to patent protection. He has combined features which achieve a new result, or at least an old result in a better way. Cf. Bates v. Coe, 98 U. S. 31, 39; Walker on Patents (Deller's Ed.) Vol. 1, p. 255, and cases there cited.
>
> "Other prior patents cited by Halliburton, as for example the patent of Tucker, No. 1,351,356, which was to aid in locating the source of gunfire, were not designed to perform the same function as Walker's tuning device, and would not, without the addition of other elements, serve the purposes of the Walker patent. The Tucker patent mentioned was among the examples of the prior art cited by the examiner. We think, too, that Walker specified and claimed his improvements with sufficient distinctness and clarity to comply with the statute."

Upon Halliburton Oil Well Cementing Company's petition for rehearing, the Ninth Circuit Court of Appeals again considered whether or not the cases of *General Electric v. Wabash* and *Davis Sewing Machine Co. v. New Departure Mfg. Co.* were applicable to the claims of the patent in suit, and in its opinion denying the petition for rehearing the Ninth Circuit Court stated [R. 1614]:

> "In its petition for rehearing appellant, Halliburton Oil Well Cementing Company, assumes that the court in ruling on Walker's patent No. 2,156,519 failed to consider the cases of General Electric Co. v. Wabash Appliance Corp., 314 U. S. 364, and Davis Sewing Mach. Co. v. New Departure Mfg. Co., 217 Fed. 775, particularly the first of these decisions. Halliburton is mistaken. In the General Electric case the claim considered was not one for a combination of elements, but a claim for a single element. Here, the claims are for a combination of elements. They sufficiently define the limits of the invention to enable those having knowledge of acoustics and of the principles of the physics of sound to determine what is covered and what is beyond the scope of the claimed invention."

In the latter opinion, Judge Denman of the Ninth Circuit Court, in concurring in the denial of the petition for rehearing, stated [R. 1614-1616]:

> "Appellant's principal contention on its petition for rehearing concerns the patenting of a combination of functional means such as claimed in typical claims 1 and 14, cited in the opinion.
>
> "Claim 1 is for a combination in
>
> "(A) 'an apparatus for determining the location of an obstruction in a well having therein a string

of assembled tubing sections interconnected with each other by coupling collars'

of the following three 'means,' with

"(B) 'means communicating with said well for creating a pressure impulse in said well,' and

"(C) 'echo receiving means including a pressure responsive device exposed to said well for receiving pressure impulses from the well and for measuring the lapse of time between the creation of the impulse and the arrival of said receiving means of the echo from said obstruction,' and

"(D) 'means associated with said pressure responsive device for tuning said receiving means to the frequency of echoes from the tubing collars of said tubing sections to clearly distinguish the echoes from said couplings from each other.'

"Each of B, C and D describes a function but, appellant contends, fails to describe how the apparatus is to perform the function, as required by R. S. 4488, 35 U. S. C. Sec. 33, cf. General Electric Co. v. Wabash, 304 U. S. 364, 368.

"No case is cited in which such a combination of means alone has been sought and the case seems of novel import. It is apparent that a combination of three means is valid only if a combination of all the various means for accomplishing each of the three functions is to be deemed included in the claim. It would establish invalidity of the patent if prior thereto any one of the several means of each of the all-inclusive means so had been combined.

"Appellant has shown no such prior combination of any one of each of the three means. General Electric Co. v. Wabash, *supra*, is distinguishable. Unlike the instant patent for a combination, the patent there was for a specific product and its production was described

in functional instead of a specific physica determinant. Since the combination of all such means has novelty and usefulness, I agree in the denial of the petition for rehearing."

In order to distinguish the principles involved in the present case from those which were considered by the Supreme Court in the *General Electric Co. v. Wabash Appliance Corp.* case, it is believed to be necessary only to compare the facts presented to the Court in the *General Electric Co.* case with those presented to the Court in the instant case.

The claim under consideration in the *General Electric Co.* case being a "single means" claim, recited as that "single means" a filament in which the grain structure of the filament was "made up mainly of a number of comparatively large grains of such size and contour as to prevent substantial sagging and offsetting during a normal or commercially useful life of such lamp or other device." The claim therefore did not of itself place any distinctive and definite limit as to what grain sizes could accomplish the result or the function desired. Certainly the claim did not set out with any definiteness how a person attempting to practice the alleged invention could determine beforehand what grain sizes would work and what other grain sizes would not work. In other words, so far as the claim sets forth and defines the invention in the Pacz patent, any person attempting to practice the invention would be required to conduct a series of experiments on filaments employing an infinite number of grain sizes until, by a laborious process of elimination, a successful filament was finally produced.

It is believed that the reason the Supreme Court held that this claim was invalid as indefinite and functional was because the claim failed to point out and to teach the art what was necessary to accomplish the desired result and left the public completely unadvised as to how to practice the alleged invention. In the *General Electric Co.* case even the disclosure in the specification was similarly lacking in any definite disclosure upon which a person attempting to practice the invention could rely with any assurance that by following the alleged teachings in the specification, a successful filament could be constructed.

Briefly stated, in the *General Electric Co. c. Wabash Appliance Co.* case, the patent under consideration was not only indefinite as to the teaching and disclosure in the specification to the extent that it failed to apprise the public as to what was necessary to permit the public to practice the alleged invention, but the claim also failed to contain language upon which the public could depend in an attempt to determine what were the limits the patentee had intended to place upon the protection granted to him.

The Court, in holding that the claim was invalid for the reasons that at the very point of novelty (the definition of the grain structure which the inventor claimed was the essential feature of his alleged new filament) the language which was selected left the public utterly uninformed, arrived at a sound decision based upon the facts of the case which were then before it. Unquestionably an inventor who has invented or discovered a new product which is allegedly successful, must, under the fundamental principles of our patent law, set forth in his specification and in his claims a teaching of sufficient particularity that it may be followed by those who later desire

to practice the invention and to achieve the result which the inventor claims is accomplished by his new discovery.

In the instant case, the inventor Walker states in his specification what the problem is which he seeks to solve; namely, the location and measurement of the height of the fluid level in a well, and in his specification he describes in clear and distinct language one embodiment of the invention which he has made for the purpose of solving that problem.

Walker defined his new contribution to this art as the combination of three distinct elements, coacting together to produce this result, namely:

(a) a means for creating the pressure impulse in the well capable of producing echoes or reflections from successively encountered obstructions in the well;

(b) a receiving and registering device to be located at the ground surface so exposed to the gas pressure existing in the well as to be effected by the gas pressure changes or disturbances resulting from the arrival at the ground surface of the reflections or echoes from the various obstructions in the well with a registering or recording mechanism for recording the successive times of arrival of the echoes from the successively encountered obstructions; and

(c) *a means associated with the first two elements which would tend to suppress undesirable and unwanted noises and reflections and tend to cause the accurate registration upon the record of the desired echoes, namely, those from the tubing collars and the fluid surface.*

In the instant case, having disclosed one embodiment of his complete three-element combination, the only way in which the applicant could define his new contribution

as distinguished from the previous two-element combinations, such as shown in the prior patents to Lehr and Wyatt [R. 1101] or the Batcheller patent [R. 1065] with any degree of breadth, was by the recitation of the three elements in terms of mechanism or "means" followed by the statement of the function each of the elements is to perform in the complete combination.

The present case therefore clearly distinguishes on the facts from the *General Electric v. Wabash Appliance* case. In the instant case there is a clear and complete disclosure whereas in the *Wabash* case there is an incomplete and ambiguous disclosure. In this case the claims are "combination" claims and the functional statements criticized serve as clear definitions of the individual elements of the combination and their cooperative relation to the other elements whereas in the *Wabash* case the claim was only a *single means claim* and the indefinite and functional statement criticized was a functional definition of the entire invention intended to cover any and all ways of accomplishing the ultimate result of making a non-sagging filament, without expressing how this result was to be achieved.

On the facts presented in the instant case the principles expressed in *Continental Paper Bag Company v. Eastern Paper Bag Company*, 28 S. Ct. 748, appear to be controlling. In the *Continental Paper Bag* case, the question which was presented to the Court was that of a combination of elements of a machine employed for the purpose of making a particular kind of paper bag, and the Supreme Court found that in the patent under consideration there, the inventor had sought to comply with Section 4888 of the Revised Statutes by filing a descrip-

tion of his invention in which he explained its principle and the best mode in which he contemplated applying that principle. Looking to the claims, the Supreme Court found that the inventor did not intend to give up all other modes of application of those principles of the invention and at page 751 the Court states:

> "An inventor must describe what he conceives to be the best mode, but he is not confined to that. If this were not so most patents would be of little worth. 'The principle of the invention is a unit, and invariable; the modes of its embodiment in the concrete invention may be numerous and in appearance very different from each other.' 2 Robinson, Patents, Sec. 485. The invention, of course, must be described and the mode of putting it to practical use, but the claims measure the invention. They may be explained and illustrated by the description. They cannot be enlarged by it."

At Page 752, the Court continues:

> "Counsel, however, contends that the circuit court, in its decision, virtually gave Liddell a patent for a function by holding that he was entitled to every means to cause the forming plate to oscillate about its rear edge.
>
> "The distinction between a practically operative mechanism and its function is said to be difficult to define. Robinson, Patents, Sec. 144, et seq. It becomes more difficult when a definition is attempted of a function of an element of a combination which is the means by which other elements are connected and by which they coact and make complete and efficient the invention. But abstractions need not engage us. The claim is not for a function, but for mechanical means to bring into working relation the

folding plate and the cylinder. This relation is the very essence of the invention, and marks the advance upon the prior art. It is the thing that never had been done before, and both the lower courts found that the machines of the Continental Company were infringements of it. It is not possible to say that the findings of those courts on that fact or on the fact of invention were clearly wrong, notwithstanding the great ability of the argument submitted against them."

The principle laid down in the *Continental Paper Bag Company* case has been consistently followed by the District Courts, the Circuit Courts of Appeals, the Court of Customs and Patent Appeals and by the United States Patent Office in determining the proper wording of claims which are directed to a combination of elements which go to make up a unitary machine. In *Davis Sewing Machine Co. v. New Departure Manufacturing Co.*, 217 Fed. 775, the Court, when presented with claims which were directed to a combination of elements defined as "means" followed by statements of function, stated at page 782:

> "But where used with reference to the make-up of the field in which the real invention finds its usefulness or with reference to the connecting parts which permit the salient novelty of the invention to accomplish its function, these words are only a convenient formula of the broadest equivalency of which the real invention permits. Their use amounts to a statement by the inventor that, as to this element, the claim is not confined to the form shown, nor to any close imitation of that form, but extends as broadly as is consistent with the extent of his inventive step to all forms accomplishing that part of the ultimate, composite result, and, of course, does

not, of itself, prevent the court (where the state of the record requires) from interpreting the claim as limited to a more or less close approximation to the 'means' described in the specification. Rich v. Baldwin (C. C. A. 6) 133 Fed. 920, 923, 66 C. C. A. 464; Kellogg Co. v. Dean Co. (C. C. A. 6) 182 Fed 991, 1003, 105 C. C. A. 545.

"That the Supreme Court has not intended, either in the Westinghouse-Boyden Case or in other instances where claims have been held void because functional, to predicate this result merely on the presence of the word 'means,' 'mechanism,' etc., is apparent. In *Morley Co. v. Lancaster,* 129 U. S. 263, on page 286, 9 Sup. Ct. 299, 32 L. Ed. 715, there was an extreme instance. The claim was for the combination of three elements: 'Button-feeding mechanism; appliances for, etc.; and feeding mechanism.' The objection that this and other similar claims were void on their face because for a function could not have escaped the attention of Mr. Justice Blatchford, who wrote the opinion sustaining their broad validity; indeed he expressly said that these claims were not for the result or effect, irrespective of the means employed. The case being, however, one of the class where the vital point of the invention — the making of the combination of these different sets of mechanism — was expressed in these general terms, it was ruled that they did not cover every possible means, but yet must be treated as terms of very considerable scope and inclusiveness. In the latest reported decision touching this point, Paper Bag Patent Case, 210 U. S. 405, 422, 28 Sup. Ct. 748, 752 (52 L. Ed. 1122), the claim called for the combination of 'a rotating cylinder, forming plate, and 'operating means for the forming plate adapted to

cause the said plate to oscillate about its rear edge, etc.' (The claim included other mention of 'means' as elements, but this is the one to which the opinion refers.) It was argued that, by extending the patent to cover a device in which the defendants used very different means of causing a forming plate to oscillate about its rear edge, the court below had given the patentee a patent for a function. The Supreme Court held, in effect, that the use of these general terms is not objectionable in cases where the element so identified serves to provide a 'working relation' for what may be called the more primary elements of the combination.

* * * * * * * *

"The Patent Office practice, in the shaping of claims with reference to these phrases, has vacillated. After some of the early court decisions disapproving the particular uses of these words which were involved in the cases decided, the Patent Office was inclined to forbid their use; but this confusion later settled down into the clearly established rule that these words would not be permitted where the novelty of the invention was in the specific mechanism to which they were intended to refer, but would be approved when they described 'mere adjunctive devices which connect or give co-operation to the various elements or features of the invention, but are in themselves no actual controlling part of it.' Ex parte Paige, 40 O. G. 807, 810; Ex parte Pacholder, 51 O. G. 295; Ex parte Halfpenny, 73 O. G. 1135. Pursuant to this rule regulating the 'substantive' and the 'adjunctive'— which we consider only another form of words for the distinction we have expressed —the great majority of patents during the last few years have contained claims identifying certain elements as for 'means,' 'mechanism,' 'devices,' etc.

"In none of the cited decisions of this court especially relied upon in argument do we find any holding that a claim calling for 'means' is thereby, and thereby only, made functional; but, if there were any such holding, it must yield to the rule of the Paper Bag Case. These considerations demonstrate to us that the call of claim 19 for 'a brake mechanism' does not make the claim functional or invalid, and that this claim is infringed. The same considerations govern the use of similar phrases and terms in claims 25-30."

Innumerable cases could be cited in which approval of the principle of permitting the inventor of a new combination to describe and define his invention in terms of "means" followed by the statement of the function the means performs in the particular combination recited in the claims, for example, *Gilchrist Co. et al., v. KarLac Co., et al.*, 29 F. (2d) 153, 154, C. C. A. 7, 1928, and *Apex Electrical Mfg. Co. v. Maytag Co., et al*, 122 F. (2d) 182, 187.

This principle which has been consistently followed by the Patent Office and by the courts is most ably stated by Judge L. Hand in *Buono et al., v. Yankee Maid Dress Corporation*, 77 F. (2d) 274-277 (C. C. A. 2, 1935):

"The only debatable matter is of the language of the claims themselves; it is the old question of how far a claim may safely be cast in terms of function. * * * The other elements of claim 6 except a single one are in mechanical terms referable to the disclosure, and are clearly not functional. The exception is, 'operating means connected to said eccentric device and turning said pivoted device at predetermined intervals.' This too is readily enough identified by the disclosure, and though it does speak in terms

of function that is inevitable to some degree, if the claim is to have any generality whatever. The very test of equivalency is in terms of function, 'the same result by the same means,' and it is only by recourse to that standard that a patentee can pass beyond the very details of his disclosure."

It is repeated therefore that what Petitioner is attempting to do in the instant case is to have this Court overrule the *Paper Bag* case and to establish a doctrine that where an inventor has devised a new and novel combination of elements and has, in the language chosen to express the elements of the new combination, employed the expression "means" followed by the statement of the function each of the elements performs in cooperation with the other elements of the combination, such choice of expression recites only the "function" and does not recite the mechanism with sufficient particularity to distinguish his invention from the prior art. If Petitioner's position is to be adopted by this Court, then it follows that no matter how meritorious an invention may be, no matter how much of an advance in the art the contribution of the inventor may be, the scope of the protection granted by his patent is only such as to cover that one specific embodiment employed by him to illustrate and describe the new contribution.

In the instant case, this would mean that even though Walker, by his addition of the new third element to the previously unsuccessful two-element combination, achieved success in the accomplishment of a result which had long been desired by the oil industry, he would be limited in the scope of the protection given him under his patent *to the particular adjustable length of pipe 18* (which he

illustrates and describes as one form of means by which the undesired noises and disturbances could be filtered out), as the means for solving the problem of determining in any particular well what the velocity of sound or pressure waves is in that well.

Petitioner bases its contention in this respect upon the fact that in the *Wabash* case the language used by the Supreme Court was a condemnation of the employment by the inventor of *indefinite* language to define the single element of novelty. In the instant case there is no indefiniteness. Certainly there is no question which could be raised by anyone skilled in the science of sound or acoustics as to what was intended to be covered by the claims of the patent in suit. The specification clearly presents the solution for the problem as consisting of the addition to the previous pressure impulse producing devices and the previous echo recording devices of a filtering mechanism which would perform the function of eliminating the interferences which had prevented the previous devices from being successful, and thereby permit the registration of tubing collar echoes, which would, by their position on the record chart, make the chart a self-calibrating record with respect to the speed of sound or pressure waves in the particular well upon which a particular record was being made.

That the language of the claims of the patent in suit was not indefinite is readily demonstrated by the fact the lower court had no difficulty in determining from the language of the claims what was intended to be covered thereby and found that the contribution which had been made by Mr. Walker was the addition to the previously unsuccessful devices of the third element of the Walker

claims which made a new combination and accomplished a new result.

In the instant case the Court is not presented with the same or corresponding facts as were considered in the *General Electric v. Wabash* case, but instead this Court is presented with facts which are readily distinguishable. In the *Wabash* case, neither the specification nor the claims constituted a guide to those skilled in the art, which would enable them to practice the invention, whereas in the instant case the principles disclosed in the specification are clear and definite. These principles are that in a sonic method of locating fluid levels in oil wells by recording echoes of a pressure impulse from a plurality of tubing collars and from the fluid surface in a well, such record may be made accurate and intelligible by utilizing the third element recited in the claims in suit, namely, a means for suppressing undesired disturbances and for filtering out of the record noises and disturbances which would prevent the accurate and clear registration of the tubing collar echoes.

The particular mechanism described in the specification and illustrated in the drawings of the patent in suit is a mechanical embodiment of these principles.

Once the patentee Walker had disclosed that the solution for the problem of obtaining tubing collar echoes as a means for calibrating the record chart was to employ a noise suppressing or filtering apparatus, it was obvious to those skilled in the science of sound that the filtering and noise suppression could be accomplished either acoustically, as specifically disclosed in the Walker patent in suit, or by converting the sound or acoustical waves into electrical impulses and then filtering the electrical impulses so produced.

Conclusion as to Question No. 1:

It is clear that the doctrine of the *General Electric Company v. Wabash* case was correct in that the patent of that case presented a claim and a disclosure, neither of which acted as a guide to the public as to what was required to practice the invention and what was intended to be covered by the claim of the patent.

It is equally clear that the doctrine stated in the *General Electric v. Wabash* case does not apply to the instant case wherein the invention involved relates to the combination of a plurality of elements which go to make up a complete unitary combination in which each of the elements coasts with the others to produce a new result *and wherein each of the elements is defined by such terms as "means," followed by the statement of the specific function each of them is to perform in cooperation with the other elements of the combination.* In accordance with the holding in the *Continental Paper Bag* case, such claims are definite and do constitute a clear statement to the public as to what is required for the practice of the invention and what is intended to be covered by the subject matter of the claim.

Argument as to Question No. 2:

With regard to the second question presented by Petitioner as to whether or not the principles expressed in *Schriber-Schroth Co. v. Cleveland Trust Co.*, 311 U. S. 211, 61 S. Ct. 235, should apply or be extended to cover the situation presented in the instant case, it should be pointed out that the facts in the *Schriber-Schroth* case and the instant case are different, as is admitted by Petitioner on page 67 of its brief. No case has been found by Petitioner in which this or any other Court has con-

sidered the situation involved in the instant case (see Petitioner's brief, page 69).

Briefly stated, the facts in the *Schriber-Schroth* case were that the patentee filed an application for patent asserting certain claims which, during the prosecution of the application, were rejected, and as a result of such rejection the patentee cancelled those claims from the application *without inserting other claims of the same scope*, and the patentee took out his patent with claims of more limited scope than those which had been originally presented and cancelled. In a subsequent suit for infringement of the patent, the patentee, suing on the more limited claims which he had accepted from the Patent Office, attempted to assert a scope for these limited claims which would make them so broad as to be equal in scope to the claims which had been rejected and had been cancelled from the application.

Obviously, under the principle that a patent is a contract and that the patentee is bound by the terms of the contract as it is finally consummated (by the grant of the patent to the inventor), the inventor is estopped from asserting that the terms of the contract are sufficiently broad to incorporate material which he had attempted to get into the contract but was unsuccessful in so doing. There appears to be no reason to question the correctness of the ruling in the *Schriber-Schroth* case since it is in conformity with well established legal principles and leads to a just result.

In the instant case, no such set of facts exists. The patentee Walker filed the application for the patent in suit, illustrating as one embodiment of his invention an arrangement of mechanical structures cooperating together to produce the result of obtaining a recording of the

location of the fluid level in an oil well which could be accurately interpreted by reason of the employment of a noise suppressing and filtering mechanism which permitted the recordation on the same record chart of a plurality of tubing collar echoes which would render the record chart self-calibrating as regards the speed of sound or acoustical waves in the particular well under measurement. In the application which resulted in the patent in suit, the patentee asserted claims such as the claims in suit which were sufficiently broad in their language to not only cover the exact mechanical devices illustrated and described in the specification but also to cover equivalents of these mechanical structures.

The patentee then filed a second application, in which he illustrated another specific embodiment of apparatus designed to produce, among other things, a record of the fluid level in an oil well, together with a record of a plurality of echoes from adjacent tubing collars as a means for self-calibrating the record chart. The apparatus disclosed in the second application for receiving and recording the echoes was an "electrical" apparatus as distinguished from a mechanical diaphragm and light beam recorder disclosed in the first application. In addition, the apparatus disclosed in the second application for filtering out and suppressing the undesirable noises and disturbances (for permitting the clean-cut and accurate registration of tubing collar echoes) was likewise an electrical apparatus as distinguished from the mechanical appartus (the pipe 18) which was disclosed in the first application.

At the time of filing the second application, the patentee Walker asserted claims in that application such as Claim 15, directed to the feature of employing, with the electrical

receiving and recording apparatus, a tuning means by which the receiving and recording mechanism was caused to respond more readily to echoes from selected obstructions in the well (tubing collars) than to gas pressure variations existing in the well emanating from other sources (such as noises).

Petitioner's position with respect to the second question presented to this Court is that because during the prosecution of the second application Mr. Walker finally acquiesced in the rejection of the subject matter of the scope of Claim 15 in that application, such acquiescence should be construed as an admission on the part of the patentee Walker that his first patent was not sufficiently broad to cover electrical apparatus such as that used by Petitioner and which has been found by the lower courts to be an infringement of the claims of the patent in suit.

In support of this position, Petitioner points out that in the second Walker application Claim 15 was directed to an electrical apparatus and would have read directly upon the apparatus employed by Petitioner, and that this Claim 15 was rejected upon the prior patent to Lehr and Wyatt. In response to such rejection, Claim 15 was cancelled. Petitioner reasons therefore that the cancellation of Claim 15 constituted an abandonment by Mr. Walker of an attempt to cover an electrical apparatus such as that used by Petitioner.

The fallacy of this position is demonstrated by a consideration of the file history of the second Walker application Serial No. 164,534 [R. 953-1063].

The subject matter which Petitioner states was abandoned by Walker by the acquiescence in the Patent Office rejection was actually not abandoned nor was any re-

jection thereof acquiesced in by Walker until the Patent Office had rejected this subject matter *as being the equivalent of the subject matter covered by the earlier Walker patent* (the patent in suit).

Claim 15, which is referred to by Petitioner as constituting this subject matter, was presented in the second application as originally filed [R. 982]. In the first action by the Patent Office this claim was rejected on the Lehr and Wyatt patent [R. 1002]. However, Walker did not abandon this subject matter though he did cancel the specific wording of this subject matter as it appeared in Claim 15. Upon amendment in response to the first Office action, Walker asserted Claim 25 as a substitute for original Claim 15, the subject matter of Claim 25 being an attempt on Walker's part to continue the assertion of claims of the same scope as Claim 15 [R. 1006, 1015.]

In the next action by the Patent Office, Claim 25 was rejected as being "indefinite" and "functional" [R. 1019-1020] but on this second action the Examiner apparently withdrew the rejection of the subject matter as unpatentable over the Lehr and Wyatt patent and, in fact, stated that the application contained patentable subject matter. In response to the second Office action, amendments and explanations were made with respect to Claim 25, the patentee Walker still insisting upon his right to receive a patent upon the subject matter of Claim 25 which had been substituted for Claim 15 [R. 1022, 1027].

Prior to the next action by the Examiner, another amendment was made to the application [R. 1030-1043], in which Claim 25 was canceled and new Claim 35, directed to the same subject matter as original Claim 15,

was inserted in the Walker application with an explanation [R. 1043] that new Claim 35 was directed broadly to this subject matter which up to that time the patentee Walker had considered he was entitled to cover in the new application.

It was only after the rejection [R. 1056] of Claim 35 as being unpatentable over Walker's own patent No. 2,156,519 (the patent in suit) and the explanation by the Examiner [R. 1058] that the electrical tuning mechanism recited in Claim 35 was the mere electrical equivalent of the mechanical tuning shown in the earlier Walker patent (the patent in suit) that Walker finally acquiesced in the rejection of the subject matter of Claim 15, for which Claims 25 and 35 had in turn been substituted.

This history therefore shows that Walker had at no time during the prosecution of either the first application which resulted in the patent in suit nor the second application, acquiesced in any holding by the Patent Office that he was not entitled to claims having a scope sufficient to cover electrical apparatus as an equivalent of the specific mechanical apparatus illustrated and described in the patent in suit.

As was stated in Respondents' brief opposing the petition for certiorari, the position which has been taken by Petitioner with respect to the facts of the instant case in an attempt to extend the doctrine of the *Schriber-Schroth* case to cover the facts of the instant case leads to an absurdity in that if Petitioner's position is sustained by this Court it will mean that a patentee who devises a new invention, a new piece of apparatus or a new combination, and applies for a patent thereon, will be effectively prevented from seeking to improve upon that

invention and attempting to secure patent protection upon the improvement by the fear that if the improvement is rejected by the Patent Office the proceedings involved in the second application will be employed to construe and interpret what was intended between the applicant and the Patent Office in the grant of a patent upon his first application. Thus it would follow that an inventor, after filing an application for patent and receiving a patent thereon, would be afraid to file a subsequent application on what he considered might be a further improvement, no matter how important or meritorious it might be, for fear that during the prosecution of the second application limitations would be imposed upon his first patent which were obviously not intended by either the inventor or the Patent Office at the time of the grant of his first patent.

Conclusion as to Question No. 2:

Petitioner's argument is based upon a misinterpretation of the facts. The subject matter canceled from the second application was not so canceled as unpatentable over the prior art but was canceled because it was shown that the subject matter was only the equivalent of the subject matter already covered by the claims of the patent in suit.

To sustain the position taken by Petitioner would, in effect, establish a rule whereby a patentee would not dare to file subsequent applications to cover what he thought were improvements for fear that the cancellation of a narrow claim from the improvement application would impose a limitation on his earlier patent claim, preventing him from covering subject matter more limited than was expressed in the claims of his earlier patent.

Conclusion.

As to Question No. 1:

1. The claims of the patent in suit are not invalid as functional since they are combination claims in which each of the elements is sufficiently defined as approved in *Continental Paper Bag Co. v. Eastern Paper Bag Co.*, 210 U. S. 405.

2. Claims to a combination are not invalid merely because they recite each of the elements thereof in terms of "means" followed by a limiting statement of the function the individual element performs in coaction with the other elements of the combination.

3. The facts of the instant case make the doctrine applied in the *General Electric Co. v. Wabash Appliance Corp.* inapplicable in that both the specification and the claims clearly define the novelty sought to be protected, whereas in the *General Electric Co.* case neither the specification nor the claims particularly pointed out what would accomplish the desired result and what would not.

As to Question No. 2:

1. The claims of the patent in suit are not to be given such limited construction as to exclude them from covering electrical equivalents of the mechanical devices disclosed in the specification and drawings of the patent in suit.

2. The claims of the patent in suit were intended by both the inventor and the Patent Office to be sufficiently broad to cover the electrical equivalents of the mechanical structure disclosed in the patent.

3. Walker's abandonment of an attempt to obtain specific claims in a second application on electrical equiva-

lents of the mechanical device disclosed in the patent in suit was not an admission on the part of the patentee that the first patent was not sufficiently broad to cover electrical equivalents, but instead was merely an acknowledgment that since the first patent (the patent in suit) contained claims sufficiently broad to cover electrical equivalents, the patentee did not need a second patent covering identically the same subject matter.

It is therefore submitted that the decision of the Circuit Court of Appeals should be affirmed.

Respectfully submitted,

HAROLD W. MATTINGLY,
Attorney for Respondents.

Los Angeles, December 27, 1945.

IN THE

Supreme Court of the United States

October Term, 1946.

No. 24.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Petitioner,

vs.

CRANFORD P. WALKER, and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a co-partnership,

Respondents.

BRIEF ON REHEARING FOR CRANFORD P. WALKER, ET AL., RESPONDENTS.

HAROLD W. MATTINGLY,
920 Pacific Finance Building, Los Angeles 14,
Attorney for Respondents.

Parker & Company, Law Printers, Los Angeles. Phone TR. 5206.

SUBJECT INDEX.

	PAGE
Statement of the case	1
History of the litigation	2
The questions presented	4
The invention	5
The invention supplied a long felt want	5
The industry needed the invention	7
No solution of problem before Walker's invention	7
Previous attempts were unsuccessful	8
Union Oil Company's experiments were unsuccessful	9
Lehr and Wyatt's results were too inaccurate	9
Walker undertook problem of producing accurate useable measurements	11
The old "two element" combination was a failure	12
Success achieved by Walker's "three-element" combination	13
The patent in suit	15
Patent drawing and specification fully disclose one embodiment	15
The claims define the novelty of the invention	16
The claims in suit	16
Petitioner's infringing activities	20
The infringement is deliberate and wilful	21
Petitioner's attempted distinctions are refuted by the record	22
Summary of the argument	25
As to Question No. 1	25
As to Question No. 2	27

PAGE

Argument 28

As to question No. 1 28

Point (1) 28

Point (2) 32

Point (3) 32

Point (4) 33

Point (5) 34

Point (6) 35

Walker's claims are definite when read by sound engineers 36

Point (7) 39

Ninth Circuit Court found Walker's claims were definite 39

Point (8) 42

Supreme Court approved this language for "combination" claims 44

Walker type of claim is type approved by courts 47

Petitioner cites no pertinent authority against Walker type claims 48

Point (9) 53

Conclusion as to Question No. 1 53

Argument as to Question No. 2 54

Conclusion as to Question No. 2 58

Conclusion 59

TABLE OF AUTHORITIES CITED

CASES.	PAGE
Allen-Bradley Co. v. Erie Resistor Corp., 104 F. (2d) 150	49
Buono et al. v. Yankee Maid Dress Corporation, 77 F. (2d) 274	47
Cohen, In re, 133 F. (2d) 924	49
Continental Paper Bag Co. v. Eastern Paper Bag Co., 210 U. S. 405	4, 26, 43, 44, 46, 47, 51, 52, 53, 59
Davis Sewing Machine Co. v. New Departure Mfg. Co., 217 Fed. 775	51
Farmers Cooperative Exchange v. Turnbow, 111 F. (2d) 728	50
General Electric Company v. Wabash Appliance Corp., 304 U. S. 364	4, 25, 26, 27, 33, 34, 35 39, 49, 50, 53, 54, 59
General Talking Pictures Co. v. Western Electric Company, 304 U. S. 175	4
Hazeltine Corp. v. Emerson Television-Radio, Inc., 129 F. (2d) 580	49
Horton, et al., Application of, 151 F. (2d) 210	48
John Bean Mfg. Co. v. Creagmile, 123 F. (2d) 182	50
Kool Kooshion Mfg. Co. v. Mitchell Mfg. Co., 102 F. (2d) 37	49
Krause v. Coe, 120 F. (2d) 717	51
Lincoln Engineering Co. v. Stewart-Warner Corp., 303 U. S. 545	50
Mead Johnson & Co. v. Hillman's, Inc., 135 F. (2d) 955	49
Minnesota Mining & Mfg. Co. v. Coe, 113 F. (2d) 512	50
Rice v. Nash Kelvinator Corp., 150 F. (2d) 457	48
Schriber-Schroth Co. v. Cleveland Trust Co., 311 U. S. 211	4, 27, 55, 56, 57, 58

PAGE

Timken Detroit Axle Co. v. Cleveland Steel Products Corp., 148 F. (2d) 267 49

Tyden v. Ohio Table Co., 152 Fed. 183 51

Universal Oil Products Co. v. Globe Oil and Ref. Co., 322 U. S. 471 50

William B. Mershon & Co. v. Bay City Box & Lumber Co., 189 Fed. 741 51

STATUTES.

Revised Statutes, Sec. 4888 15

IN THE

Supreme Court of the United States

October Term, 1946.
No. 24.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Petitioner,

vs.

CRANFORD P. WALKER, and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a co-partnership,

Respondents.

BRIEF ON REHEARING FOR CRANFORD P. WALKER, ET AL., RESPONDENTS.

Statement of the Case.

This case is before this Court for rehearing on a Writ of Certiorari granted by this Court at a time when Justice Jackson was absent in Europe. Before the original hearing on January 9, 1946, briefs were filed by both petitioner and respondents and were considered by the remaining eight justices. At the first hearing, the Court was equally divided and a *per curiam* order was entered affirming the decision of the Ninth Circuit Court of Appeals, which Court had held the patent in suit valid and

infringed by petitioner Halliburton Oil Well Cementing Company.

At the oral argument on January 9, 1946 Justice Reed was ill and absent from the bench during the entire hearing and Justice Murphy was also ill and present for only a part of the argument.

Upon a petition for rehearing filed by Halliburton Oil Well Cementing Company, a rehearing was granted to permit re-argument of the case before a full bench.

HISTORY OF THE LITIGATION:

Cranford P. Walker, the inventor, as owner of the patent, and Depthograph Company, a small co-partnership consisting of the inventor, Mr. Walker, his wife D. A. Walker, Milo C. Ketchum and Robert P. Miller, exclusive licensee under the Walker patent in suit, were operating a small service business rendering a service to various oil companies of locating the fluid level in oil wells, the pay for which service was the sole income of the partnership.

On July 16, 1941 plaintiffs Cranford P. Walker and Depthograph Company (respondents here) filed suit against Halliburton Oil Well Cementing Company, (petitioner here) for infringement of the Letters Patent in suit.

After trial in the District Court for the Southern District of California, a decision was entered by the District Court holding the patent in suit valid and infringed by Halliburton.

Petitioner Halliburton appealed from that decision to the Circuit Court of Appeals for the Ninth Circuit and

on December 28, 1944 the Ninth Circuit Court of Appeals affirmed the decision of the District Court and found that the patent in suit was valid and infringed by Halliburton.

Petitioner Halliburton then filed in the Ninth Circuit Court of Appeals a petition for rehearing before that Court, which petition was denied on June 12, 1945 and a *per curiam* opinion was entered, together with a concurring opinion written by Judge Denman, specifically considering the very questions presented to this Court by the Petition for Writ of Certiorari.

As pointed out above, after the filing of briefs on certiorari in this Court and the presentation of a full oral argument in January, 1946, resulting in the split decision noted above, petitioner Halliburton requested rehearing, stating as its grounds for urging a rehearing that the original hearing had not been had before a full Court.

It appears evident from the foregoing that petitioner Halliburton, a wealthy corporation involved in many activities relating to the oil industry, has utilized every legal device to prolong this litigation and, as will appear from a consideration of the questions presented for decision by this Court, has used as one of the devices for prolonging the litigation and for increasing the expense of this litigation to Walker and Depthograph, the assertion of its contentions as to principles of law which are wholly without merit and are untenable.

The Questions Presented.

Stripped of the many side issues touched upon in petitioner's briefs, actually the two questions petitioner is apparently presenting to this Court are as follows:

(1) Does the position of the Supreme Court in *General Electric Company v. Wabash Appliance Corp.*, 304 U. S. 364, overrule the principles stated in the case of *Continental Paper Bag Co. v. Eastern Paper Bag Co.*, 210 U. S. 405, and which have been consistently followed since 1907 by this Court and the lower courts in considering claims in patents directed to *machines comprising a combination of several pieces of mechanism cooperating together to produce a new result*; and

(2) Can the doctrine expressed by this Supreme Court in *Schriber-Schroth Co. v. Cleveland Trust Co.*, 311 U. S. 211 be so distorted as to permit its application to an entirely different state of facts and result in penalizing the inventor for attempting to improve a device upon which he has received patent?

Under the guise of asking this Court to determine only the two questions raised by its petition, petitioner's brief attempts to argue questions of novelty, anticipation and lack of invention, all of which questions are not before this Court and these arguments must be ignored (*General Talking Pictures Co. v. Western Electric Company*, 304 U. S. 175).

The statements which appear on the following pages of petitioner's brief are impertinent and certainly not addressed to the issues before this Court.

Page 29—The Patent Office and both lower courts held that the Lehr and Wyatt patent No. 2,047,974 did not disclose the invention in suit. This question is not now before this Court.

Page 45—The lower courts found petitioner has infringed the claims in suit and this Court cannot now review the question of infringement. Only the question of validity is before this Court.

Page 56—Both lower courts found the invention was a *new combination* and that the claims did not define an *old combination.* This question is not here for review.

Page 63—The lower courts did not find that there was only "one novel element" but found that the three-element combination was new over the prior two element combinations.

Pages 68 through 76—All of this argument is addressed to the question of infringement by petitioner's apparatus and this matter is not here for review.

The Invention.

THE INVENTION SUPPLIED A LONG FELT WANT:

In order for this Court to properly consider the questions presented by petitioner, a brief review should be made of the history of the development of the invention of the patent in suit and the contribution which it has made to the oil industry. Briefly stated, the invention of the patent in suit is directed to the solution of a problem which has long faced the oil industry but which had had no satisfactory solution until the invention by Walker of the apparatus illustrated, described and claimed in Letters Patent No. 2,156,519.

In the production of oil from oil wells, the well bore extends from the ground surface down through various earth strata into the oil bearing sand formation to tap the underground pool of oil. The oil in the underground formation is usually under considerable pressure due to the gases which have been trapped in the earth above the liquid oil and due in part to the downward forces exerted by water in the formations above the oil pool.

Thus when the well bore penetrates into the oil bearing sands, these pressures tend to force the oil from the formation into the well bore and upwardly in the well bore toward the ground surface. If the natural pressures in the earth formation are sufficiently high, the oil is forced upwardly in the well bore all the way to the ground surface and the well is known as a "flowing well."

If, however, the pressures are insufficient to force the oil up to the ground surface, a mechanical pumping apparatus must be inserted in the well bore to a position below the surface of the liquid column which has been forced into the well bore and the mechanical pump is then operated to lift the oil the remaining distance to the ground surface where it may be used.

If the pump is of sufficient capacity, it will remove the oil from the well bore as rapidly as the earth formation pressures force the oil into the well bore whereas if the pump has a lesser capacity or is operated less efficiently, it will remove the oil at some lower rate. On the other hand, if the pump is operated in such fashion as to remove the oil more rapidly than it flows into the well from the formation, the pump will operate inefficiently due to the fact that it will lower the standing column of fluid in the well bore down to the pump inlet and thereafter at

each stroke of the pump only a small quantity of liquid will enter the pump, the balance of the capacity of the pump merely pumping gas from above the surface of the liquid column.

THE INDUSTRY NEEDED THE INVENTION:

It has long been known by the oil industry that if the oil engineers could know or determine where the top of the fluid column in the well bore was located relative to the pump inlet *while the pump was actively pumping oil from the well,* the engineers could determine

(a) whether or not the pumping apparatus was adequate to produce oil from the well in an efficient manner; and

(b) in cases where either government regulation or voluntary agreement by the oil companies made it necessary or desirable to produce oil from the well at a small proportion of the maximum capacity of the well, the pumping apparatus could be selected and operated at a rate such as to produce oil from the well with assurance that the production rate would be that which had been fixed by the oil umpire or by the government regulation.

NO SOLUTION OF PROBLEM BEFORE WALKER'S INVENTION:

However, in spite of the fact that it had long been known that this information was desirable, and in spite of the fact that many ingenious attempts had been made to determine the information, namely, how high in the well bore is the surface of the oil column *while the pump is actively operating,* no system or apparatus existed which

would give any satisfactory and accurate answer until the invention in the patent in suit was made by Mr. Walker.

To appreciate the difficulty of the problem which was solved by the invention in the patent in suit, the Court should keep in mind the fact that an oil well is a relatively small diameter hole extending for thousands of feet down into the earth and that the oil well includes a "casing" or pipe which is inserted into the earth bore to make a metal lining for the earth bore. Then down through the casing there is extended a "flow tubing" or smaller pipe, upon the lower end of which the actual pump is located and the oil pumped by the pump flows upwardly to the ground surface through this flow tubing.

PREVIOUS ATTEMPTS WERE UNSUCCESSFUL:

One of the previous attempts to obtain the information as to the location of the fluid surface in the well was that of attempting to insert in the annular space between the small flow tubing and the larger casing a pipe or tube or wire which, if it could be lowered a sufficient distance to reach the surface of the liquid column in the well, would give an indication at the ground surface as to the location of the fluid surface. This was totally unsuccessful for the reason that while the well bore is theoretically straight, actually it is more in the shape of a corkscrew and at one point in the well the flow tubing will touch one side of the casing while at other points in the well it will touch other sides of the casing, making a barrier against the insertion of any metal device all the way from the ground surface to the top of the fluid column.

UNION OIL COMPANY'S EXPERIMENTS WERE UNSUCCESSFUL:

The record of this case shows that prior to Mr. Walker's invention at least two other attempts had been made to obtain the fluid level location information by "sonic" methods, namely, the introducing of a sound into the well, and measuring the location of the fluid surface by attempting to time the passage of the sound from the ground surface down through the well and its reflection back to the ground surface from the top of the fluid column. There is testimony to the effect that in 1927 the Union Oil Company made some experiments along this line but these were so unsuccessful that they were abandoned. [R. 512-513.]

LEHR AND WYATT'S RESULTS WERE TOO INACCURATE:

In the years 1931 and 1932 Harold Wyatt and Paul Lehr, employed by the Shell Oil Company, started experiments with sound apparatus of the type which later resulted in the Lehr and Wyatt patent No. 2,047,794 [R. 1102-1105], in which they attempted to locate fluid levels in oil wells by creating a sound or pressure wave ("pressure wave" as used in the patent in suit meaning a pressure wave having all of the characteristics of a sound wave except that it may be below the range of detection by the human ear) in the annular space between the flow tubing and the casing and measuring the time which elapses between the creation of the pressure wave and the arrival at the ground surface of

its reflection from the top of the fluid column. The Lehr and Wyatt theory was that the pressure or sound wave would travel down and back up through the well in accordance with the known laws of physics relating to sound, namely, that the sound would travel at a fixed rate of speed.

Lehr and Wyatt discovered, however, that the rate of speed of sound was different for each well that they measured. This is due to the difference in the character of the gas in the well from the character of the gas in an adjacent well, and to the difference in temperature in one well from the temperature existing in an adjacent well. Hence the results obtained by Lehr and Wyatt did not give truly the location of the fluid surface and their attempt to obtain accurate information as to the location of the fluid surface was baffled.

Lehr and Wyatt then suggested that a sample of the gas in each well should be analysed as to its character, its pressure and its temperature and they devised a methematical formula by which they hoped they could determine the rate of speed of sound in any particular well under measurement *but again they discovered that even the corrective mathematical formula did not give them accurate results,* probably due to the fact that in any given well the character of the gas and its temperature varied between wide limits between the ground surface and the top of the oil column.

WALKER UNDERTOOK PROBLEM OF PRODUCING ACCURATE USEABLE MEASUREMENTS:

In October, 1935 Lehr and Wyatt, having been unsuccessful in obtaining any accurate fluid level measurements, entered into an agreement with Walker whereby Walker was to attempt to perfect and commercialize a satisfactory fluid level measuring apparatus. [R. 156.]

Walker started experimenting, using the apparatus which Lehr and Wyatt had already constructed and throughout the months of October and November, 1935 Walker experimented with this apparatus and found that it was unsatisfactory. [R. 169.]

Walker made additional apparatus during December, 1935 and January and February, 1936, among which pieces of apparatus was a "calibration tube" which is illustrated at 53 in the patent in suit, the purpose of which was to permit a sample stream of gas from the well under measurement to flow through the calibration tube while apparatus associated with the tube was supposed to measure the sound-speed characteristics of the gas in that well.

While this calibration tube gave better results than had been previously obtained by anyone, it was still not entirely satisfactory and the system did not give accurate results but only a closer approximation than had ever before been achieved.

From March, 1936 to March, 1937 Mr. Walker attempted to interest oil companies in using the fluid level measuring system but encountered difficulty due to the fact that the accuracy of the results was not as good as was required by the oil industry.

THE OLD "TWO ELEMENT" COMBINATION WAS A FAILURE:

For the purposes of this hearing, Mr. Walker's apparatus comprised in effect two basic elements or pieces of mechanism:

(1) a means for producing a sound or pressure impulse in the annular space between the casing and the flow tubing of the well (in the patent in suit, the apparatus connected to the well including a tank of gas 11, a gas chamber 12 and a quick opening valve 16 by which a "slug" of gas could be suddenly injected into the well to create a sound wave or acoustical wave which would travel down and back through the well); and

(2) a means or apparatus for recording on a moving record strip

(a) the instant of the creation of the pressure wave in the well; and

(b) the instant of the arrival back at the ground surface of the reflection of the wave from the surface of the fluid column (in the patent in suit, this apparatus is the diaphragm mechanism 22, the diaphragm 23 of which will move when the well gas is disturbed by the change in pressure resulting from the injection of the gas "slug" and the arrival of the echo from the fluid surface to move the small mirror 26 to draw a line upon the record chart 39, as illustrated in Fig. 2, the peak *b* representing the instant of injection of the gas into the well and the peak *d* representing the arrival of the reflection from the fluid surface).

Were it not for the fact that the speed of sound in different wells is not uniform, and not the same as it is in air the length of time it took the record tape 39 to move the distance between the peaks *b* and *d* multiplied by the normal speed of sound in air (1100 feet per second) should tell how many feet below the ground surface the fluid surface in that particular well was located; but as pointed out in the patent in suit the speed of sound in one well may be 800 feet per second while in another well it may be 1400 feet per second, and Mr. Walker had no way of accurately knowing the exact speed of sound in any well under measurement.

SUCCESS ACHIEVED BY WALKER'S "THREE-ELEMENT" COMBINATION:

In March, 1937 [R. 196] Mr. Walker made the invention in the patent in suit, by adding to the previously used apparatus elements 1 and 2 above, a mechanism which would allow the recording on the record tape 39 the echoes or reflections from each of the couplings in the flow tubing pipe (the flow tubing in a well is usually made up of a considerable number of sections of pipe of approximately uniform length, either about 20 feet or about 30 feet, connected together by pipe couplings slightly larger in diameter than the diameter of the flow tubing pipe so that the couplings form a shoulder extending into the annular space between the flow tubing and the casing, which shoulder will, like the fluid surface, reflect back a part of the sound wave passing through the well).

Walker's invention consisted therefore in recognizing that if he could record on the record tape the echoes from all of the tubing couplings or if he could record the echoes from at least a number of successively adjacent couplings, he could measure the distance along the tape occupied by the recordings of the tubing coupling echoes and knowing the length of each of the pipe sections between the couplings, the distance along the tape between the peaks *d* and *b* could be accurately computed since that distance would be exactly proportional to the distance along the tape occupied by the tubing collar echo recordings.

To accomplish this result of making recognizable recordings of the tubing collar echoes, Mr. Walker used as this third element:

> (3) a piece of mechanism [R. 196] which would filter out other noises and vibrations [R. 239 and 777] and make the recorder more responsive to the frequency of the approximately evenly spaced recurring echoes from the tubing collars. [R. 196.]

Instantly Walker had created this new 3-element combination in place of the previously used 2-element combination, he achieved fluid level measurements of such great accuracy that even the oil engineers to whom he demonstrated his apparatus would not believe that the results were true.

Thus Mr. Walker's addition of the third element to the old 2-element combination produced success in the accurate measurements of fluid levels in wells whereas all previous attempts had resulted only in failure.

The Patent in Suit.

The patent in suit describes the problem which was attacked by and solved by Walker and describes the requisite features of an apparatus to accomplish the result of accurately measuring the fluid levels in oil wells.

PATENT DRAWING AND SPECIFICATION FULLY DISCLOSE ONE EMBODIMENT:

In compliance with the requirements of Section 4888, R. S., Mr. Walker illustrates and describes in detail one embodiment of the invention as comprising mechanical apparatus consisting of:

(1) a means for producing a pressure or sound wave in the annular space between the well casing 2 and the flow pipe 5, the apparatus specifically illustrated and described being apparatus for suddenly injecting a quantity of gas into the space from a gas measuring chamber 12 loaded with a supply of gas from a tank 11 and from which the gas is suddenly released into the well by means of a quick opening valve 16;

(2) a means for receiving and recording the changes in gas pressure within the well, resulting from

(a) the sudden injection of the "slug" of gas; and

(b) the arrival at the ground surface of the reflections or echoes of the pressure or sound wave reflected from the fluid surface 6 and each of the couplings (tubing collars) 10 in the flow tubing 5, the apparatus specifically described and

illustrated being the diaphragm 23, the light beam reflecting mirror 26 and the recording tape 39; and

(3) a means for "accenting" the recordings of the echoes from the tubing collars so as to recognizably record such tubing collar echoes and to filter out and suppress other extraneous noises and disturbances [R. 239 and 777] which might interfere with the clean-cut recording of the tubing collar echoes, the specific apparatus illustrated and described comprising a tube 18 connecting the diaghragm 23 with the well casing and adapted to have its length adjusted to approximately one-third the length of a section of the flow tubing 5 between a pair of adjacent couplings or collars 10.

THE CLAIMS DEFINE THE NOVELTY OF THE INVENTION:

The Court must remember that the novelty in the Walker invention is not that the third element in itself is new but that *it was new to use the third element in combination with the other two elements.* The claims define the new invention in terms of "means" for each of the three elements and defines each of these "means" by a definition of what type of structure is required, what its function is, and how it must work in combination with the other elements.

THE CLAIMS IN SUIT:

The claims in suit are as follows:

1. In an apparatus for determining the location of an obstruction in a well having therein a string of assembled tubing sections interconnected with each other by coupling collars,

means communicating with said well for creating a pressure impulse in said well,

echo receiving means including a pressure responsive device exposed to said well for receiving pressure impulses from the well and for measuring the lapse of time between the creation of the impulse and the arrival at said receiving means of the echo from said obstruction, and

means associated with said pressure responsive device for tuning said receiving means to the frequency of echoes from the tubing collars of said tubing sections to clearly distinguish the echoes from said couplings from each other.

13. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings,

means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from the couplings and other obstructions in said well,

echo receiving and registering means coupled to said well to expose said receiving and registering means to pressure variations produced in said well by echoes from said obstructions, and

means associated with said receiving and registering means to accent the registration of tubing coupling echoes.

14. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings,

means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from couplings and other obstructions in said well,

pressure responsive echo receiving and registering means coupled to said well to expose said receiving and registerng means to pressure variations in said well produced by echoes from said obstructions, and

interference eliminating means associated with said receiving and registering means for limiting the response of said receiving and registering means to the registration of echoes from actual obstructions in the well whereby the registered echoes of the tubing couplings may be readily distinguished from each other and from the echoes from other actual obstructions in the well.

15. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings,

means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from the couplings and other obstructions in said well,

pressure responsive echo receiving and registering means coupled to said well to expose said receiving and registering means to the pressure variations produced in said well by echoes from said obstructions, and

resonance means associated with said receiving and registering means to produce therein a natural acoustical period of oscillation so related to the frequency of the echoes from the tubing couplings as to accent the registration of the tubing coupling echoes.

17. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings,

means communicating with said well for creating therein a pressure impulse to produce echoes of said impulse from the couplings and other obstructions in said well,

pressure responsive echo receiving and registering means

having a natural frequency of oscillation so related to the frequency of the echoes from said tubing couplings as to accent the registration of said echoes, and

means interconnecting said receiving and registering means to said well to expose said receiving and registering means to pressure variations in said well.

Petitioner's Infringing Activities.

Petitioner Halliburton Oil Well Cementing Company is a fairly large corporation engaged in many and varied activities in the oil industry, only a part of which is performing for the oil producing companies fluid level measurements by means of its apparatus which it calls the "Echo-Meter." Petitioner purchased this part of its business in May, 1940, after it had investigated patents relating to this type of activity and after it had full knowledge of the Walker patent in suit [R. 709].

Petitioner purchased this "Echo-Meter" business from International Geophysics, Inc., which company, directed by Mr. J. J. Jakosky, had been engaged in operating the "Echo-Meter" system (Petitioner's Brief, p. 18) in direct competition with Mr. Walker's Depthograph Company, and which company had been formally notified by Walker that its activities were an infringement of the patent in suit [R. 710].

The history of Jakosky's company was that in late 1936 the Union Oil Company requested Mr. Jakosky to develop a fluid measuring apparatus which would compete with Mr. Walker's Depthograph apparatus which Walker had been commercially exploiting (Petitioner's Brief, p. 17). In November, 1936 Mr. Jakosky visited a well at which Walker was making measurements with his Depthograph apparatus [R. 203-204] and took photographs of the mechanism Walker was then using.

About July, 1937 [R. 204] Mr. Walker discovered that Mr. Jakosky's company, International Geophysics, Inc., was in the field making fluid level tests with the same type of infringing mechanism and apparatus which have been used by petitioner Halliburton Oil Well Cementing

Company subsequent to its purchase in 1940 of the "Echo-Meter" business.

THE INFRINGEMENT IS DELIBERATE AND WILFUL:

In view of the fact that Halliburton purchased the Jakosky—International Geophysics "Echo-Meter" system *after having full knowledge of the Walker patent*, it is obvious that the infringement was deliberate and wilful and that petitioner started its activity with full knowledge of Walker's inventions and patents, obviously in the hope that, by reason of its size, its wealth and its ability to conduc. prolonged and expensive litigation, it could pirate Walker's contribution to the oil industry and obtain the sanction of the Courts to its activities.

In its brief petitioner dwells at some length upon the "differences" between the apparatus it employs and that specifically illustrated and specifically described in the patent in suit but it nowhere denies that its apparatus includes the three elements of the Walker patented combination, namely:

(1) a means for producing a pressure impulse in the well, namely, a gun 10 for firing a cartridge or shotgun shell into the annular space between the casing 1 and the flow tubing 2 of an oil well [R. 713 and petitioner's brief, pp. 21-22];

(2) a means for registering and recording the echoes of the pressure or sound waves from the fluid surface and couplings of the flow pipe; and

(3) a means for filtering out extraneous noises and thus render the recorder more sensitive to clearly record the tubing collar echoes, namely, the construction of the electrical amplifier and filter 21 used with elements 1 and 2 above.

While petitioner purports to be presenting to this Court only two specific questions of law to be considered by this Court, in its brief it diverges from this to include arguments directed to questions of comparisons of specific structure shown in the patent and that used by petitioner, to questions of the equivalency of such structures, and to questions of patentability over prior art, none of which should be considered by this Court in determining the answers to the two questions upon which certiorari was granted.

PETITIONER'S ATTEMPTED DISTINCTIONS ARE REFUTED BY THE RECORD:

However, since petitioner's brief does dwell upon these items, it will be helpful to this Court to note that petitioner's assertion on page 35 of its brief that its electrical filter and amplifier does not have a "natural frequency of oscillation" as called for specifically in Claim 17; that it is not a "tuning" device as called for specifically in Claim 1; that it is not resonant as called for specifically in Claim 15; and that it does not "accent" the tubing collar echoes as called for in Claims 13 and 14, are refuted by its own expert, Dr. MacKeown, who on cross-examination admitted that petitioner's filter *raises the tubing collar echoes above the level of other noises* by cutting down disturbances more than it cuts down the signal (tubing collar echoes) [R. 455]; that the *amplifier-filter combination acts to suppress all unwanted frequencies* and leaves the tubing collar frequencies at some distinguishable point above them [R. 456]; that the filter has a *natural period of oscillation corresponding to the frequency of tubing collar echoes* [R. 469]; while petitioner's own

instruction manual for the use of its device [Exhibit 11-C, R. 735-737] states:

"The electrical filter is designed to filter and selectively amplify the frequency produced by reflections from the tubing collars. * * * In addition to its switching action this control adjusts the amount of energy fed back from the output to input circuits of the amplifier. This energy causes the amplifier to have a *tendency to oscillate at the frequency* for which the filter is set. * * * With higher settings the *tendency to oscillate increases.* The Feed-back should never be increased to a point where oscillation (14) occurs without some exciting signal to start it * * * When using the filter on a well, one record should always be made in the usual manner with the Decrement turned 'Off.' By measuring as many tubing collars as possible on this record the average joint length on the record is then determined. * * * Then, referring to the calibration curve for the filter, the setting corresponding to this record length †is used. * * * If this is done the calculated fluid depth may be in error, if the frequency setting of the filter is not *exactly the same as the collar frequency of the well.* When it is difficult to get good collars the feed-back control should be set so that when the transducer volume control (16) is set at the maximum necessary for the well the push button will cause the filter to *generate oscillations* for not over 10 cycles. The filter will give the transducer an over-all *amplification somewhat greater than normal for signals of the frequency for which the filter is*

†The printed record, page 736, should have been corrected by the insertion of the words "is used." ahead of the expression "of frequency inasmuch as variations in the recorder motor speed will change the apparent frequency of the filter." and that the expression beginning "of frequency" should have been omitted to make the printed record conform with Exhibit 11-C as introduced in evidence.

> *set.* This amplification increases as the feed-back is increased. The filter will have a tendency to decrease the sharpness of the fluid, tubing catcher, and liner top breaks on the record and in some cases it will be necessary to record these points on one record without the filter and then use the filter to improve the tubing collars on the record." (Italics ours.)

These admissions by petitioner's expert and these instructions in petitioner's instruction manual clearly demonstrate:

(a) that the electrical filter used by petitioner is adjusted or "tuned" to the frequency of the tubing collar echoes (compare with Claim 1);

(b) that it has a natural frequency of oscillation (compare with Claim 17);

(c) that it is designed to *"filter and selectively amplify the frequency produced by reflection from the tubing collars."* (Compare with Claims 13, 14 and 15.)

(d) and that it is an "interference eliminating means." (Compare with claim 14.)

In addition, petitioner has urged throughout this litigation [R. 396] that its filter is like that shown in the Scott patent, Exhibit 0-13 [R. 1108-1131] in which patent it is stated:

> "The present invention relates to electric systems, and more particularly to systems for selecting predetermined frequencies from currents or voltages containing a number of different frequencies."

Also on page 5 of this patent, beginning in line 63 in Column 1 and extending through line 8 in Column 2, there is described the manner in which the filter may be adjusted (tuned) for different frequencies.

Summary of the Argument

As to Question No. 1:

(1) It is clear from the file history of the patent in suit that both Walker and the Patent Office intended the claims in suit to cover electrical apparatus such as is used by petitioner.

(2) It is clear that the Patent Office knew of the apparatus used by petitioner and its predecessor and intended that such apparatus was to be considered the equivalent of the apparatus specifically illustrated and described in the patent in suit.

(3) It is evident that Walker's claims in suit are not indefinite since they define Walker's new combination of three elements, each of which is admitted by petitioner to have been known in the art. Hence when Walker's claims recite the three necessary elements, the mechanisms intended are readily identifiable as known devices and their identification in the claims is amply sufficient to tell those skilled in this art what types of apparatus must be selected and how they can be combined to practice Walker's new invention.

(4) The only doctrine established by *General Electric Company v. Wabash Appliance Co.*, 304 U. S. 364, is that the claims must define the limits of the invention in a manner understandable by those skilled in the art to which the invention relates so that at least those members of the public may know what lies within the scope of the claim and what lies without.

(5) While the opinion in the *General Electric v. Wabash* decision uses language condemning the use of *only* functional statements to define the invention, the facts of

that case were that the claims were so vague and indefinite in defining the size of tungsten grains which would work and those which would not that they failed to define the invention and left the public (those skilled in the art) uninformed as to what was covered and was not covered.

(6) The facts in the instant case distinguish from the *General Electric v. Wabash* case in that here Walker's claims to the invention are clear and complete, leaving the public *fully informed* as to how to select known mechanisms for every element in his new combination *and with no necessity to perform further experiments to determine what will work and what will not.*

(7) The doctrine of the *General Electric v. Wabash* case does not apply in the instant case because the facts in the *General Electric* case were that the claim was not for a combination of mechanisms but was for a "single means," the single means or element constituting all of the purported new invention, the claim was so broad as to fail to define that *single* means with enough particularity to advise the public what would work and what was intended to be covered by the claim.

(8) In defining an invention in a new combination of several element mechanisms, the use of language such as "means" and "mechanism" followed by the definition of such means by a statement of how the means is to work in the combination was approved in 1907 in *Continental Paper Bag Company v. Eastern Paper Bag Company*, 210 U. S. 405, and since that time that mode of expression has been the criterion of the manner in which a patentee may obtain some measure of breadth in his claims.

(9) To distort the *General Electric v. Wabash* doctrine as petitioner urges here, would automatically limit all patent claims to the specific embodiment shown in the drawings and described in the specification of the patent and no claim would cover equivalents selected by an infringer in an effort to pirate the invention by evasion.

As to Question No. 2:

(10) The facts of the instant case are so different from those in the case of *Schriber-Schroth Co. v. Cleveland Trust Co.*, 311 U. S. 211, that the doctrine of that decision does not apply here.

(11) To distort the *Schriber-Schroth* doctrine as petitioner urges here, would penalize a patentee if he attempted to secure additional patents on improvements subsequent to the issue of his first patent.

(12) A patentee who has received a broad patent on his invention and in a later improvement application acquiesces to a ruling by the Patent Office that his later improvement does not amount to invention over what was originally protected in his first patent, is not thereby estopped to urge the claims of his first patent are as broad as the Patent Office originally intended them, since to so hold would be to alter the terms of a patent contract by events which occurred after the contract was executed.

(13) That petition urges under question No. 2 such an unwarranted and absurd contention to this Court is another demonstration of petitioner's attempts to unduly prolong this litigation at the expense of the patentee.

Argument.

AS TO QUESTION NO. 1:

Point (1):

In its attempt to urge this Court to find that the electrical apparatus employed by the petitioner is not the equivalent of the specific structure illustrated and described in detail in Walker's patent, petitioner urges (on page 34 of its brief) that there was no basis for assuming that in drawing the claims in suit Walker intended to cover the use of an electrical filter or that the Patent Office intended to grant Walker a monopoly on such use. This is specifically contradicted by the record in this case, particularly the following:

(1) The file history of the patent in suit [Ex. T, R. 1416-1544] shows that on February 11, 1939 a petition was made to the Commissioner of Patents to make action on this application special because of the competitive activities of petitioner's predecessor, International Geophysics, Inc. [R. 1516-1518], and that the Commissioner on February 13, 1939 granted the petition to make this application special, the very purpose of which was to secure claims in this patent to cover the electrical apparatus then being used by International Geophysics, Inc., later purchased by petitioner and now being used by petitioner.

Not only did Walker intend the claims of this patent to cover the type of electrical apparatus now being used by petitioner but *the Patent Office in granting the petition to make the application special has evidenced the intention of the Patent Office that*

the claims should extend to and cover the very type of apparatus which respondent in this case complains is an infringement of his claims.

(2) On the face of the patent in suit there is exhibited the clear intention of both Walker and the Patent Office that this patent should cover not only the tuning pipe 18, but also other equivalent mechanisms which could be used for the purpose of carrying the patented invention into practice.

For evidence of that, the Court's attention is called to the fact that Claims 2 and 3, for example, are narrow claims directed to the specific structure disclosed by Walker, namely, "a pipe coupling said pressure responsive device to the well, means for adjusting the effective length of said pipe to tune said pressure responsive device to one of the harmonics of echoes of said impulse received from the coupling collars of said tubing string." The claims in suit which were also granted by the Patent Office are not so limited in their language. *By the very grant of the broader claims it is clear that not only Walker expected the broader claims to cover other apparatus but that the Patent Office also expected the broader claims to cover apparatus considered equivalent to the specific embodiment shown and described in the drawing and specification.*

In a copending application filed by Walker with the intention of covering certain details of an electrical apparatus designed by Walker [Exhibit L], claims addressed to the use of an electrical tuning device for the purpose of accenting the tubing collar echoes were rejected by the

Patent Office as unpatentable over the Walker patent in suit as follows:

> †"Claim 35 is rejected as defining nothing patentable over Walker 2,156,519. The Walker patent discloses means for tuning mechanically to the selected echo, but it is obvious that electrical tuning could be used instead in a system comprising an electrical receiving circuit. The two species are not patentably different." [R. 1046-1047.]

while at 1060 in the same file history the Examiner states:

> "The equivalence of electrical tuning and mechanical tuning for selective reception was thought to be so generally recognized that citation of an illustrative reference was not considered necessary. In view of applicant's request for further explanation, however, the Holland patent is referred to as one illustration of the interchangeability of mechanical and electrical tuning for selection purposes."

---

†Claim 35 of that application reads as follows:

> "35. In a system of receiving and translating pressure echoes from a well, a microphone adapted to translate pressure variations impinging thereon into variations of electric current, means coupling said microphone to said well to expose said microphone to gas pressure in the well, means responsive to variations of said electric current, for describing an observable wave pattern reproduction of the pressure variations in said well, an electric circuit including said microphone and said current responsive means, and electrical tuning means interposed in said circuit between said microphone and said current responsive means for causing said current responsive means to respond more readily to periodically recurring echoes from a series of similar obstructions spaced substantially uniformly along the well than to echoes from pressure variations emanating from other sources." [R. 1039.].

It is obvious, therefore, that in the grant of the Walker patent it was intended by both Walker and the Patent Examiner that within the terms of the patent "contract" was to be included protection to Walker for both the specific mechanical embodiment illustrated and described in the drawings and specification and also electrical equivalents of such structure *and the petitioner's apparatus was specifically intended by the Patent Office and Walker to be covered by the claims in suit.*

Petitioner in its brief at page 36 attempts to minimize the effect of the action by the Patent Office in the file history of the patent in suit by stating that "We submit that consideration of an Examiner's statements for this purpose is improper." That consideration of such statements by a Patent Office Examiner is not only proper but is exceptionally helpful to this Court is demonstrated by the fact that such expressions are expressions of an expert opinion by the Patent Office.

Note that the file history, Exhibit L, is a part of *petitioner's own evidence* in this case.

Petitioner now seeks to avoid the consequences of petitioner's own introduction of the file history of Walker's electrical patent [Petitioner's Exhibit L] after petitioner had insisted on Walker's producing this file history and insisted on making it a part of petitioner's evidence at the trial. [R. 514.]

From the foregoing it is obvious that *both Walker and the Patent Office knew about the apparatus used by petitioner's predecessor and that Walker's patent was intended to cover the very apparatus now being used by petitioner.*

Point (2):

From the foregoing consideration of the file history of the two applications, Petitioner's Exhibits T and L, there is but one conclusion which can be drawn, and that is that it was intended that the apparatus used by petitioner was to be considered the equivalent of the apparatus specifically illustrated and described in the specifications of the patent in suit.

Point (3):

In urging this Court to consider Walker's claims as indefinite, petitioner defeats its own purpose by pointing out in its brief that each of the elements of Walker's 3-element new combination was individually old and known to the art (Petitioner's Brief, pp. 10 and 18). Hence Walker's definition of each of the elements of this new combination by reciting the type of apparatus or mechanism each element must be and by pointing out how each of these elements cooperates with the other in his new combination, he is referring to known mechanisms and is definitely instructing the public what to select to make up the new combination and defining to the public exactly the scope of the invention and of the claims.

Instead of Walker's claims being indefinite, petitioner, in effect, admits that Walker's claims teach the selection of old and known "means" and how to combine them into his new 3-element combination without requiring further experimentation to determine what means will work and what will not.

Point (4):

All of petitioner's argument addressed to the support of its contention that the decision of the Supreme Court in *General Electric Co. v. Wabash Appliance Corp.*, 304 U. S. 364, is an attempt to have this Court misconstrue the language of that decision to cover a set of facts entirely distinct from and distinguishable from the facts in the instant case.

In the *General Electric Company* case the Court was presented with the following facts:

(a) The patentee was attempting to obtain a patent for a particular kind of lamp filament for an electric lamp in which the filament would not sag while in use;

(b) The specifications of the patent taught only that the inventor had discovered that if the grain size of the tungsten particles used in making the filament was properly selected, a non-sagging filament would result;

(c) It does not appear from the opinion where the patentee anywhere disclosed that he had discovered the limits of the range between the largest particles that would work and the smallest particles that would work; and

(d) In the claim there was no definition of the limits of grain size which the patentee claimed would work to distinguish from grain sizes which would not accomplish the desired result but instead the claim in effect stated "I claim any grain size which will produce a non-sagging filament," and thus the claim does not inform the public as to what is intended to

be covered by the patent and what would be outside of the scope of the claim.

In the *General Electric Company* case the Court found that the inventor had failed to set forth in his claim the limits of his invention by failing in the claim to specify the difference between what would work to accomplish the result and what would not.

The Court did not in that case establish a doctrine that a statement of function used in a claim in an attempt to correctly define the limits of the claim was fatal or necessarily bad. The Court in that case merely repeated the well established patent law principle that an inventor must define his invention in such manner as to teach the public how to practice his invention and inform the public what was outside the scope of the claimed invention.

Point (5):

In expressing its decision in the *General Electric Company* case, the Court at 371 used the language:

> "A patentee may not broaden his product claims by describing the product in terms of function."

In effect, the actual decision in the *General Electric Company* case and the only decision which could be entered by the Court under the facts presented in that case was that the patentee's claim was void for lack of any definition of the limits of his invention.

Petitioner has grasped, *not at the import of the General Electric Company case, but at merely a few words of the language expressing the decision,* and is urging this Court to extend the principle laid down in that case to cover

a totally different situation in which there is no question as to the adequacy of disclosure or the definition of the limits of the invention in the claim.

Point (6):

The facts in the instant case are entirely distinct from the situation presented to this Court in the *General Electric Company* case. Here even petitioner does not question the adequacy and completeness of the disclosure in the patent in suit of one embodiment of apparatus which will accomplish the new result obtained by Mr. Walker.

While petitioner urges that the claims are indefinite in their use of expressions such as "means," followed by a statement of the function of each of the means and how it cooperates with the other mechanism in the combination, petitioner cannot say that the public is not fully apprised of what type of mechanism would be selected by anyone attempting to practice the teachings of the Walker patent. In fact, petitioner argues that all such mechanisms were old and were known. Hence there is no indefiniteness in the Walker claims since those claims contain a full and complete definition of the limits of the invention and the limits of the type of mechanism which must and can be used to achieve Mr. Walker's new result.

Moreover, petitioner in its argument overlooks and is strangely quiet as to the fact that each of the expressions defining Walker's third element in each of the claims is not merely a "means" but is a definition of a particular kind of means.

In Claim 1 the third element is recited as a "tuning" means.

In Claim 13 the third element is recited as an "accenting" means.

In Claim 14 the third element is recited as "interference eliminating" means for "limiting the response of the receiving means" to certain frequencies.

In Claim 15 this third element is defined as a "resonance" means while in Claim 17 it is recited as a means having "a natural frequency of oscillation."

WALKER'S CLAIMS ARE DEFINITE WHEN READ BY SOUND ENGINEERS:

Every engineer dealing with sound, acoustics, electricity, radio and phonographs knows that "interference eliminating" means may be either an acoustical means such as a pipe of given length or may be an electrical filter in an electric circuit which translates the acoustical sound waves into electrical waves. Every such engineer knows that "resonance means" may be a pipe or box of known dimensions as an acoustical resonator or may be a tuned electric circuit such as is employed by the petitioner. Every such engineer knows that an "accenting" means for the purpose of accenting certain desired frequencies and suppressing other undesired frequencies may be either a mechanical device such as a pipe or tube or box of known dimensions or may be an electrical filter tuned to the desired frequency and when so tuned they will suppress the passage of other frequencies. Every such engineer knows that a means having "a natural frequency of oscillation" may be either a mechanical device which has a natural oscillation frequency corresponding to some acoustical wave frequency or it may be an electrical device such as a filter or

tuned electrical circuit which has some selected natural frequency of oscillation.

Hence Mr. Walker's claims being addressed to those skilled in the art teaches these engineers and these persons skilled in the art the kind of mechanism which must be used as the third element of Walker's new combination to achieve the new Walker result. As stated by petitioner, *all of such mechanisms were old and known to those skilled in this art.*

Far from being indefinite, Walker's claim 1 states clearly to the sound engineer: "Select from the tools of your trade a known 'tuning' device, acoustical or electrical, tune it to the frequency of the tubing collar echoes, and connect it with the recording means. It will suppress other frequencies and you will get clear readable tubing collar records." Claim 15 tells him to select a known device of the "resonance" type; Claim 14 tells him to select a known type of device which is known from his previous engineering knowledge will limit the recording means to record known selected frequencies. Claim 13 tells him to select a known device which from his previous knowledge he knows will pass the tubing collar frequencies and suppress other frequencies to thus accent the recording of the tubing collar choes. Claim 17 tells him to add to the pressure responsive echo receiving and registering mechanism a device which will act with the recording mechanism to give the system a natural frequency of oscillation corresponding to the tubing collar echo frequencies and that if he chooses a known device having these known characteristics he will make the tubing collar recordings more clearly registrable and recognizable.

Walker's invention was not in building his tube or pipe of a given length—*it was his recognition of the fact that by tuning his system to the frequency of the tubing collar echoes the record would be accurate and self-adjusting for the speed of sound in the particular well under measurement.* The problem was a little more complex than is indicated in the foregoing statement of the fundamentals by reason of the fact that joints in the casing produced echoes somewhat similar to the tubing collar echoes and other disturbances would resemble tubing collar echoes. Walker had discovered that by tuning his system to the average frequency at which the echoes from the tubing collars arrived at the ground surface, the result would be a clear recording of these echoes and the suppression of other disturbances, such as reflections from the casing joints.

Having taught how to make and use his *three*-element combination, the particular apparatus to be used as the third element was available for selection and use. This, petitioner admits.

More important perhaps is the fact that once a teaching was made in the specification of the Walker patent, those skilled in the art had no difficulty in selecting either electrical or mechanical apparatus to make up the combination. Even petitioner nowhere indicates that it had difficulty in finding out what apparatus could be used *after it knew of Walker's disclosure and the principles of the Walker invention.*

Certainly nothing in the record of this case even purports to indicate that anyone had to perform *experiments* to determine what type of apparatus would work in Mr. Walker's claimed combination.

Point (7):

The instant case can be further distinguished from the *General Electric v. Wabash* case in that the claims in the *General Electric* case are not directed to a machine or a combination of machine elements but instead are directed to a *product,* which product was not only a *single element device.* Moreover, the single element was the sole part of the purported invention. Hence the failure of the patentee's claim to even define that one element was fatal. In the instant case the invention claimed is a 3-element combination, in which the three elements, if put together in the manner taught by Walker in his specification and clearly defined by Walker in each of his claims, will accomplish the new result.

NINTH CIRCUIT COURT FOUND WALKER'S CLAIMS WERE DEFINITE:

As is most aptly stated by Judge Denman of the Ninth Circuit Court of Appeals in his opinion in the instant case [R. 1614-1616]:

> "Appellant's principal contention on its petition for rehearing concerns the patenting of a combination of functional means such as claimed in typical claims 1 and 14, cited in the opinion.
>
> "Claim 1 is for a combination in
>
> "(A) 'an apparatus for determining the location of an obstruction in a well having therein a string of assembled tubing sections interconnected with each other by coupling collars' of the following three 'means,' with
>
> "(B) 'means communicating with said well for creating a pressure impulse in said well,' and

"(C) 'echo receiving means including a pressure responsive device exposed to said well for receiving pressure impulses from the well and for measuring the lapse of time between the creation of the impulse and the arrival at said receiving means of the echo from said obstruction,' and

"(D) 'means associated with said pressure responsive device for tuning said receiving means to the frequency of echoes from the tubing collars of said tubing sections to clearly distinguish the echoes from said couplings from each other.'

"Each of B, C and D describes a function but, appellant contends, fails to describe how the apparatus is to perform the function, as required by R. S. 4488, 35 U. S. C. Sec. 33, cf. General Electric Co. v. Wabash, 304 U. S. 364, 368.

"No case is cited in which such a combination of means alone has been sought and the case seems of novel import. It is apparent that a combination of three means is valid only if a combination of all the various means for accomplishing each of the three functions is to be deemed included in the claim. It would establish invalidity of the patent if prior thereto any one of the several means of each of the all-inclusive means so had been combined.

"Appellant has shown no such prior combination of any one of each of the three means. General Electric Co. v. Wabash, *supra* is distinguishable. Unlike the instant patent for a combination, the patent there was for a specific product and its production was described in functional instead of a specific physical determinant. Since the combination of all such means has novelty and usefulness, I agree in the denial of the petition for rehearing."

Certainly Mr. Walker has made a meritorious invention in solving a problem for the oil industry that in spite of many attempts no one before him had succeeded in solving.

As stated by Judge Healy in the opinion of the Ninth Circuit Court of Appeals in the instant case [R. 1599-1600]:

> "Walker made a very substantial improvement over Lehr and Wyatt, notwithstanding it is conceded that both his recorder and his amplifier, considered by themselves, are old in the art. We think the patentee displayed a measure of inventive genius entitling him to patent protection. He has combined features which achieve a new result, or at least an old result in a better way. Cf. Bates v. Coe, 98 U. S. 31, 39; Walker on Patents (Deller's Ed.), Vol. 1, p. 255, and cases there cited.
>
> "Other prior patents cited by Halliburton, as for example the patent of Tucker, No. 1,351,356, which was to aid in locating the source of gunfire, were not designed to perform the same function as Walker's tuning device, and would not, without the addition of other elements, serve the purposes of the Walker patent. The Tucker patent mentioned was among the examples of the prior art cited by the examiner. We think, too, that Walker specified and claimed his improvements with sufficient distinctness and clarity to comply with the statute."

Also in the opinion of the Ninth Circuit Court of Appeals on a petition for rehearing, Judge Healy stated [R. 1614]:

> "In its petition for rehearing appellant, Halliburton Oil Well Cementing Company, assumes that the

court in ruling on Walker's patent No. 2,156,519 failed to consider the cases of General Electric Co. v. Wabash Appliance Corp., 314 U. S. 364, and Davis Sewing Mach. Co. v. New Departure Mfg. Co., 217 Fed. 775, particularly the first of these decisions. Halliburton is mistaken. In the General Electric case the claim considered was not one for a combination of elements, but a claim for a single element. Here, the claims are for a combination of elements. They sufficiently define the limits of the invention to enable those having knowledge of acoustics and of the principles of the physics of sound to determine what is covered and what is beyond the scope of the claimed invention."

Point (8):

When the invention disclosed in a patent is an apparatus made up of the combining together of several different pieces of mechanism to accomplish a new result, the inventor is entitled to claims which are sufficiently broad as to cover not only the typical specific embodiment of that apparatus which is chosen to be illustrated in the drawing and described in the specification as *one form in which the invention may be practiced,* but also to cover other specific forms of the elements which go to make up the combination.

The only way in which the invention may properly be expressed if the claims are to have any breadth is to use broad inclusive terms in reciting each of the component elements which go to make up the combination.

For many years it has been recognized that the proper manner—in fact, the only manner in which such claims may be couched in broad terms—is to define the elements

as a "means" or "mechanism" followed by a statement of the functions which the "means" is to perform in combination with the other elements of the combination.

This manner of drafting claims of breadth directed to a combination of mechanisms was approved many years ago in the case of *Continental Paper Bag Company v. Eastern Paper Bag Company*, 210 U. S. 405, and this approved manner of drafting that type of claim has been the pattern and criterion to which substantially all claims to combinations of machine elements have been drawn.

In no case prior to petitioner's contention here has that mode of expression for claims to a combination been criticized *where the several elements of which the* combination is made are old and known in the art prior to the inventors' combining together these old and well known elements to form a new machine and to perform a new result. In no case cited by petitioner has a criticism been directed to claims of this type on the ground that they are indenite or "functional" where the inventor has combined together a number of known pieces of machinery but has combined them in a new way to produce a new result. Petitioner admits that each of the separate elements defined in the Walker claims was old and well known, and further petitioner asserts that those specific elements which it employs were also old and well known. The only things petitioner does not admit is that petitioner's gun is well recognized in the art as a substitute for the tank of gas and quick opening valve of the patent in suit; that the electrical recorder with its microphone is a well known mechanical equivalent and substitute for a diaphragm-mirror-light beam recorder for recording changes in gas pressure in pipes, vessels and the like;

and that an electrical filter is so commonly recognized in the field of physics of sound as a means for filtering out or suppressing undesirable noises and permitting the desired frequencies of sound to more readily pass through the electrical system and to stand out (be accented) above the undesired extraneous noises and is considered by engineers in this field of sound as a substitute for an acoustical filter such as a predetermined length of pipe or tubing shown in the patent in suit. [But see MacKeown, R. 336, 435, 346-348.]

Thus the Walker claims express each of the three elements of the Walker new combination with ample particularity to tell the public, and particularly those members of the public familiar with the art to which the invention relates, *exactly what apparatus can be used to successfully practice the Walker invention.*

SUPREME COURT APPROVED THIS LANGUAGE FOR "COMBINATION" CLAIMS:

In the case of *Continental Paper Bag Company v. Eastern Paper Bag Company*, 210 U. S. 405, 28 Sup. Ct. 748, one of the claims under consideration is set out on page 750 as follows:

> "'In a paper bag machine, the combination of a rotating cylinder provided with one or more pairs of side-folding fingers adapted to be moved toward or from each other,
>
> a forming plate also provided with side-forming fingers adapted to be moved toward or from each other,
>
> *means for operating said fingers at definite times during the formative action upon the bag tube,*

operating means for the forming plate adapted to cause the said plate to oscillate about its rear edge upon the surface of the cylinder during the rotary movement of said cylinder;

the whole operating for the purpose of opening and forming the bottom of the bag tube,

and means to move the bag tube with the cylinder.'" (Italics ours.)

Also at 750, the Court states:

"'The pith of . . . (the) invention,' the circuit court said, 'is the combination of a rotating cylinder with means for operating the forming plate in connection therewith, limited, however, to means which cause the plate to oscillate about its rear edge.'"

Thus in 1907 the Supreme Court when considering a claim to a new combination of machine elements expressed its approval of the choice of language to define the invention as a "means" followed by the statement of the function such element is to perform in combination with the remaining elements.

At 751, the Court states:

"We think it is clear that the court considered that Liddell sought to comply with Sec. 4888 of the Revised Statutes (U. S. Comp. Stat. 1901, p. 3383). In other words, he filed a description of his invention, explained its principle and the best mode in which he 'contemplated applying that principle' and did not intend to give up all other modes of application. An inventor must describe what he conceives to be the best mode but he is not confined to that. *If this were not so most patents would be of little*

worth. 'The principle of the invention is a unit, and invariable; the modes of its embodiment in the concrete invention may be numerous and in appearance very different from each other.' 2 Robinson, Patents, Sec. 485. The invention, of course, must be described and the mode of putting it to practical use, but the claims measure the invention." (Italics ours.)

and at 752, the Court states in considering the breadth of language in which the invention was expressed in the claim:

"The distinction between a practically operative mechanism and its function is said to be difficult to define. Robinson, Patents, Secs. 144 *et seq.* It becomes more difficult when a definition is attempted of a function of an element of a combination which is the means by which other elements are connected and by which they coact and make complete and efficient the invention. But abstractions need not engage us. The claim is not for a function, but for mechanical means to bring into working relation the folding plate and the cylinder. This relation is the very essence of the invention, and marks the advance upon the prior art. It is the thing that never had been done before, and both the lower courts found that the machines of the Continental Company were infringements of it. It is not possible to say that the findings of those courts on that fact or on the fact of invention were clearly wrong, notwithstanding the great ability of the argument submitted against them."

Thus in the *Continental Paper Bag* case, the Court, when faced with a consideration of claims to a combination in which the elements were defined as "means" fol-

lowed by the statement of the function that means was to perform in the combination, approved that mode of expression in spite of the fact that the very same contention as is here expressed by petitioner was urged in that case as an argument that the claims were improperly worded.

WALKER TYPE OF CLAIM IS TYPE APPROVED BY COURTS:

It is too well known that this approval of the mode of expression of combination claims in the *Continental Paper Bag* case has been cited and followed in innumerable subsequent patent infringement decisions and no purpose would be accomplished by attempting to list here the many subsequent decisions which cite and follow the principle expressed in the paper bag decision.

In the case of *Buono et al. v. Yankee Maid Dress Corporation*, 77 F. (2d) 274, in considering a claim to a combination expressed in language of "means" followed by a statement of the function the means will perform in the combination, Judge Learned Hand states at 277:

> "The only debatable matter is of the language of the claims themselves; it is the old question of how far a claim may safely be cast in terms of function. * * * The other elements of claim 6 except a single one are in mechanical terms referable to the disclosure, and are clearly not functional. The exception is, 'operating means connected to said eccentric device and turning said pivoted device at predetermined intervals.' This too is readily enough identified by the disclosure, and though it does speak in terms of function that is inevitable to some degree, if the claim is to have any generality whatever.

The very test of equivalency is in terms of function, 'the same result by the same means'; and it is only by recourse to that standard that a patentee can pass beyond the very details of his disclosure. * * * In the case at bar the phrase was justified because the invention did not reside in the mechanical train connecting the eccentric with the table, but in a train which should tilt it at intervals longer than the oscillations of the rib. *The details not being important, the general notion so embodied the inventors might protect."*

PETITIONER CITES NO PERTINENT AUTHORITY AGAINST WALKER TYPE CLAIMS:

Petitioner, on pages 50 through 68 of its brief, cites some twenty-eight cases as condemning the "means" language to define a new combination. None of them are pertinent and the instant case is readily distinguishable from the facts in each of them as follows:

(1) *Rice v. Nash Kelvinator Corp.*, 150 F. (2d) 457

The specifications did not tell how to determine the size of the capillary tube and the public would have to resort to *experiment* to find out how to practice the invention (See page 460 of the report).

The capillary tube was a *new* element, not one "old in the art" as petitioner admits were Walker's individual elements.

(2) *Application of Horton, et al.*, 151 F. (2d) 210

Some claims were refused *as reading upon* prior patents. Decision does not condemn all "means" type of claims, *in fact*, the Court granted two other claims defined in "means" language. (See Claims 34 and 46, page 210 of the report.)

(3) *Kool Kooshion Mfg. Co. v. Mitchell Mfg. Co.*, 102 F. (2d) 37

The Court's decision was on "non-infringement," and did not rule on validity. Quoted statement is only *dicta*.

(4) *Allen-Bradley Co. v. Erie Resistor Corp.*, 104 F. (2d) 150

The claim was like that of *General Electric Co. v. Wabash* case—*a single means product* claim. The claim was "meaningless" (see page 152 of the report).

(5) *Hazeltine Corp. v. Emerson Television-Radio, Inc.*, 129 F. (2d) 580

This was not a claim using "means" limited by its function. The Court did not rule on validity but this case turned on "non-infringement."

(6) *In re Cohen*, 133 F. (2d) 924

The claims were refused, *not because of the type of language* but as readable on prior art. The only language criticised was for the reason that the material was not disclosed in the specification. (See page 928 of the report)

(7) *Timken Detroit Axle Co. v. Cleveland Steel Products Corp.*, 148 F. (2d) 267

The claims were held invalid over prior art because of *lack of disclosure in the specification to support them*, not because of the "means" type of language.

(8) *Mead Johnson & Co. v. Hillman's, Inc.*, 135 F. (2d) 955

The claims were for a *product* and were single means claims. The Court found them *invalid* as "no invention over prior art."

(9) *Minnesota Mining & Mfg. Co. v. Coe,* 113 F. (2d) 512

The claim was a *product* claim and was *anticipated by prior art.* (See pages 513, 514 of the report.)

(10) *Universal Oil Products Co. v. Globe Oil and Ref. Co.,* 322 U. S. 471

Claims were *process* claims, held invalid for *lack of invention.*

(11) *John Bean Mfg. Co. v. Creagmile,* 123 F. (2d) 182

The quoted statement is *dicta* only. The claims were held invalid *for want of invention and anticipation.*

(12) *Farmers Cooperative Exchange v. Turnbow,* 111 F. (2d) 728

The claims were *product* claims and failed to specify the "quantity or proportion of the ingredients." The holding of invalidity was correct since the facts were the same as those in the *General Electric Co. v. Wabash* case.

(13) *Lincoln Engineering Co. v. Stewart-Warner Corp.,* 303 U. S. 545

The attack here was that the *entire combination was old* and that the improvement was merely an improvement in one of the elements. This is no ruling on how to define a *new* combination, as in the *Walker v. Halliburton* case.

(14) *Krause v. Coe*, 120 F. (2d) 717

The claims were not the Walker type of claims. There was no question raised as to the claim language and the *claims were refused for lack of invention.* (Why petitioner cites this case is a mystery, unless it is because the now Chief Justice Vinson wrote the opinion.)

(15) *Tyden v. Ohio Table Co.*, 152 Fed. 183

While the language of the opinion refers to function, the decision actually hinged on the fact that the *entire combination was old* and Claim 1 failed to define over the prior art. In a later case, *William B. Mershon & Co. v. Bay City Box & Lumber Co.*, 189 Fed. 741, at 749, the *Tyden* decision was explained as follows:

"In that case, the means shown was so ordinary and common, and the device so lacking in invention, * * * as to compel the conclusion that the patentee intended to claim the *result*, by whatever means accomplished.' (Italics ours.)

(16) *Davis Sewing Machine Co. v. New Departure Mfg. Co.*, 217 Fed. 775

This case specifically approved the "means" terminology in defining a combination of elements and cites the *Paper Bag* case as follows, on pages 783 and 784:

"In the latest reported decision touching this point (the Paper Bag Case) * * * The Supreme Court held, in effect, that the use of these general terms is

not objectionable in cases where the element so identified serves to provide a 'working relation' for what may be called the more primary elements of the combination. * * *

"In none of the cited decisions of this court especially relied upon in argument do we find any holding that a claim calling for 'means' is thereby, and thereby only, made functional; but, if there were any such holding, it must yield to the rule of the Paper Bag Case. These considerations demonstrate to us that the call of claim 19 for 'a brake mechanism' does not make the claim functional or invalid, and that this claim is infringed. The same considerations govern the use of similar phrases and terms in claims 25-30." (Parenthetical insert ours.)

(17) Referring to *Continental Paper Bag Co. v. Eastern Paper Bag Co.*, 210 U. S. 405, petitioner attempts, on pages 58 to 60 of its brief, to distort the language of the *Paper Bag* opinion to say in effect that functional statements directed to *the novel element* were disapproved. The opinion there was that the novelty in the patent *was in the combination* and that the "means" clauses *were not for a function* but were the only proper way to define the "mechanical means to bring into working relation the folding plate and the cylinder. This relation is the very essence of the invention and marks the advance upon the prior art."

(18) None of the cases cited by petitioner on pages 61 and 62 of its brief were decided upon the proposition advanced by petitioner and a discussion of them would only needlessly lengthen this brief.

Point (9):

Petitioner is here seeking to have this Court distort its decision in the *General Electric Company v. Wabash* case to apply the doctrine to a completely different state of facts and to a completely different type of claim than was considered in the *General Electric* case. To do so will be for this Court to overrule the approval of the type of claim which was approved in the *Paper Bag* case and in effect to hold that the entire scope of protection to the patentee Walker is limited to the very details of the one form or embodiment chosen by Walker to illustrate and teach the principles of his invention.

To do so would in effect require this Court to establish an entirely new principle in the law of patents, namely, that no matter how meritorious an invention, no matter how much of an advance the inventor had made in the art, the only protection he can obtain is limited to the specific details of one embodiment of mechanism to practice his invention. To do so would not only destroy the protection which the Patent Office clearly intended to give to the patentee Walker but would utterly destroy thousands of patents on meritorious inventions in machine combinations.

CONCLUSION AS TO QUESTION NO. 1:

From the foregoing it is clear that both Walker and the Patent Office were fully cognizant of the specific electrical type of apparatus now used by petitioner and both fully intended that the very claims in suit should cover petitioner's apparatus. It is clear that the Patent Office, as an expert tribunal on what types of apparatus are the equivalents in patent law to other apparatus, fully

recognized the equivalency of petitioner's apparatus to the specific embodiment Walker discloses in the drawing and specification of his patent. It is clear that had Walker and the Patent Office not recognized such equivalency, then all of the claims of Walker's patent would have been limited to the specific embodiment, as was Claim 2.

It is clear that in the *General Electric Company v. Wabash* case this Court was faced with facts completely different from those in the instant case in that the type of invention was different (a single element claim) and the language of the claim did not set out the invention in any manner which would apprise the public as to what grain sizes would fall within the terms of the claim and what would be excluded.

In the instant case Walker fully disclosed the principles of his invention, in detail described one form or embodiment of the invention, and defined his new contribution in the claims in language which clearly informs the public what is covered and what is not.

It follows that each of the claims in suit is valid and is infringed by petitioner's apparatus.

ARGUMENT AS TO QUESTION NO. 2:

The fallacy of petitioner's reasoning as to Question No. 2 is so apparent as scarcely to merit consideration. In fact, at the original hearing in this case in January, 1946, petitioner's counsel thought so little of this question that he devoted his entire argument to Question No. 1.

In effect, petitioner is contending that if a patentee is granted a patent with broad claims and later in a second

application seeks specific claims to an improvement and in the latter application the Patent Office holds that the improvement is not patentable over his first patent, then the Courts must find that patentee's acquiescence to the rejection in his later application automatically extends a limited interpretation to the broad claims in his first patent.

The absurdity of such position is made apparent by the fact that if petitioner's contention was the law, an inventor who had received a broad patent upon his invention would not dare file an improvement application for fear that in the prosecution of that application the cancellation of a rejected claim to the improvement would limit his first patent so that it could not cover known and recognized equivalents of the structure broadly claimed in the first patent.

Petitioner admits that the facts in the instant case are entirely different from those considered in the *Schriber-Schroth Co. v. Cleveland Trust Co.* case and has admitted that no case can be found which supports the position petitioner urges here.

Briefly stated, the facts in the *Schriber-Schroth* case were that the patentee filed an application for a patent upon a piston and did not in the original application attribute any virtue to making the webs of the piston flexible. Later in the prosecution of the application by amendment there were inserted *in that same application* claims specifically reciting flexibility of the webs, which claims were subsequently canceled as the result of an interference and the claims in suit were inserted in the application *omitting reference to the flexibility of the webs.*

In the subsequent litigation on the claims which were allowed, the patentee urged that the patent claims included the feature of flexibility of the webs.

The Court in the *Schriber-Schroth* case found that the patentee had never asserted that the flexible webs were his invention and, in fact, by cancelling such claims from his application, admitted that he was not the inventor of the flexible webs. Then the Court rightly held that the claims which were allowed could not be construed to cover a construction which the inventor admitted was not his invention.

In the instant case the facts are totally different. Walker filed the application which resulted in the patent in suit, disclosing one embodiment of his invention and claiming his invention in broad claims (the claims in suit) and in other narrow claims such as Claim 2. The Patent Office allowed the patent in suit with the broad claims and also with the narrow claims specific to the embodiment illustrated and described.

In a subsequent and independent application, Exhibit L, Walker disclosed electrical apparatus which among other things would accomplish the result of obtaining fluid level measurements by the combination of certain electrical apparatus. During the prosecution of the second application, a claim, Claim 35, which was specific to the electrical apparatus, was rejected by the Patent Office as being merely the equivalent of the structure described and claimed in his earlier patent and hence unpatentable over

the disclosure and the claims of Walker's earlier patent, the patent in suit. The Patent Office, in effect, stated to Walker:

> "The subject matter of Claim 35 is already included in and covered by your earlier patent and a claim to the same subject matter will not be given to you in this later application."

Walker then acquiesced to the rejection and canceled Claim 35.

In the *Schriber-Schroth* case the patentee canceled the claims including flexibility of the webs because it was not a part of his invention. In the instant case Walker canceled the electrical apparatus claims because the Patent Office *ruled that the patent in suit already contained claims adequately covering the electrical apparatus.*

It follows that Walker's acquiescence was merely an acknowledgment that the patent in suit was enough to protect him against another's use of electrical apparatus and to attempt to construe this acknowledgment as an admission that his first patent did not cover electrical means is as absurd as to say an acknowledgment that a thing is black is to admit that it is white.

To follow petitioner's reasoning would create the absurd situation that one patent contract, having been entered into by the Patent Office and the inventor giving to the inventor broad claims covering his invention, could have its terms subsequently altered by subsequent negotiations between the inventor and the Patent Office in another application for a subsequent patent contract.

To construe the terms of one contract, one may examine the negotiations *which led to that contract* but it is im-

proper to examine subsequent negotiations leading to an entirely different and independent contract to interpret or limit the terms of the previous contract.

Particularly it is both bad law and bad reasoning to say that the negotiations expressed in the file history of a subsequent application can be used to alter the terms of a previously granted patent when the file history of the previously granted patent so obviously shows the intention that the previous patent should cover the electrical apparatus. As pointed out above, the file history, Exhibit T, which resulted in the patent in suit, clearly evidences the intent by both Walker and the Patent Office that the claims of that patent should cover electrical apparatus such as that used by petitioner.

CONCLUSION AS TO QUESTION No. 2:

From the foregoing it is clear that the doctrine expressed in *Schriber-Schroth Co. v. Cleveland Trust Co.*, decision was merely that it is proper to consult the file history of the application which resulted in a patent in suit to determine what the inventor admitted was not his invention as a means of interpreting the scope of the claims in that patent. It is equally obvious that that decision set up no precedent permitting the inspection of the file history of a subsequent patent as a means of limiting the scope of claims which had previously been granted in another and earlier patent.

Most obvious of all, it was not the intention of this Court to establish any principle which would make a patentee fearful of attempting to patent improvements upon a previously patented device because by so doing he would impose limitations upon the claims of his early

patent *contrary to the intent, fully expressed in the first patent, that that patent was to be broadly construed.*

Petitioner is certainly grasping at straws to impose upon this Court the obligation of even considering a so distorted viewpoint.

Conclusion.

It is respectfully submitted therefore:

(1) That the patent in suit adequately discloses the patentee's invention and teaches the public how to practice the invention;

(2) That it was the intention, both of the Patent Office and Walker, that the claims in suit were to be broader than merely cover the specific embodiment of the invention illustrated and described;

(3) That it was the intention of both Walker and the Patent Office that the claims in suit should be construed to cover the apparatus of the type used by petitioner;

(4) That the definition of the invention in the claims of the patent in suit is clear, concise and clearly informs the public of the limits of the invention covered thereby;

(5) That the facts of the instant case are so clearly distinguishable from the facts of the *General Electric Co. v. Wabash Appliance Corp.* case that the principle applied in that decision cannot be invoked to invalidate the claims of the Walker patent;

(6) That petitioner is seeking to have this Court overrule the principles approved in the *Continental Paper Bag Company v. Eastern Paper Bag Company* case and in effect to limit *all* of the claims of a patent to cover only

the specific embodiment used in the drawing and specification to teach the principles of the invention;

(7) That petitioner is seeking to have this Court establish the principle that no matter how meritorious an invention may be or how broad the intended scope of the claims, the patentee must in his drawing and specification illustrate and describe *every conceivable equivalent of his preferred embodiment of the invention;*

(8) That the intendedly broad claims of the patent are not to be limited in their scope by the patentee's admission in a later application that electrical apparatus is the full equivalent of the mechanical apparatus disclosed in the patent in suit and that such equivalents are covered by the claim in suit.

It is therefore respectfully submitted that the claims of the patent in suit are valid, that they are infringed by petitioner's apparatus, and that the decision of the Circuit Court of Appeals should be affirmed.

Respectfully submitted,

HAROLD W. MATTINGLY,
Attorney for Respondents.

Los Angeles, California,
October 10, 1946.

FILE COPY

Office - Supreme Court, U. S.
FILED
FEB 16 1946
CHARLES ELMORE CROPLEY
CLERK

IN THE

Supreme Court of the United States

OCTOBER TERM, 1945.

No. [redacted] 24

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation, *Petitioner*,

v.

CRANFORD P. WALKER AND CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER AND MILO C. KETCHUM, doing business as Depthograph Company, a copartnership, *Respondents*.

PETITION BY THE HALLIBURTON OIL WELL CEMENTING COMPANY FOR REHEARING OR OTHER RELIEF AND FOR STAY OF ISSUANCE OF MANDATE.

EARL BABCOCK,
Duncan, Okla.,

HARRY C. BOBB,
Woodward Bldg.,
Washington 5, D. C.,
Attorneys for Petitioner.

PRESS OF BYRON S. ADAMS, WASHINGTON, D. C.

TOPICAL INDEX.

Page

The Case of General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, Should be Interpreted..... 3

The Case of Schriber-Schroth v. Cleveland Trust Co., 311 U. S. 211, Should be Considered in Connection with the Facts in This Case 9

AUTHORITIES.

CASES:

Allen-Bradley Company v. Erie Resistor Corp., 104 F (2d) 150, CCA-3 5

Baltimore & Ohio R. R. v. Kepner, 313 U. S. 597, 85 L. Ed. 1550 2

Bernards v. Johnson, 313 U. S. 597, 85 L. Ed. 1550.. 2

Cohen, In Re, 133 F (2d) 924, C. C. P. A. 6

Cole v. Ralph, 252 U. S. 286, 64 L. Ed. 567..... 10

Continental Paper Bag Co. v. Eastern Paper Bag Co., 210 U. S. 405 8

Davis Sewing Machine Co. v. New Departure Mfg. Co., 217 F. 775, CCA-6 8

Farmers Cooperative Exchange v. Turnbow, 111 F (2d) 728, CCA-9 8

General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, 82 L. Ed. 1402 ..... 3, 4

Gray v. Powell, 313 U. S. 596, 85 L. Ed. 1550..... 2

Halliburton Oil Well Cementing Co. v. Walker et al., 146 F (2d) 817, CCA-9 ..... 1, 3

On rehearing, 149 F (2d) 896 3

Hazeltine Corporation v. Emerson Television-Radio, Inc., 129 F (2d) 580, CCA-2 6

Home Insurance Co. v. New York, 134 U. S. 594, 33 L. Ed. 1025 2

Horton, et al, 151 F (2d) 210, C. C. P. A. 4

John Bean Mfg. Co. v. Creagmile, 123 F (2d) 182, CCA-9 7

Kool Kooshion Mfg. Co. v. Mitchell Mfg. Co., 102 F (2d) 37, CCA-8 5

Lesenba v. State of California, 313 U. S. 597, 85 L. Ed. 1550 2

Page

Mayor of New York v. Miln, 8 Peter 120, 33 U. S. 120, 8 L. Ed. 888 ..... 2, 3
Mead Johnson & Co. v. Hillman's Inc., 135 F (2d) 955, CCA-7 7
Minnesota Mining & Mfg. Co. v. Coe, 113 F (2d) 512, Court of Appeals, Dist. of Columbia 7
Railroad Commission of California v. Pacific Gas & Electric Co., 302 U. S. 771, 82 L. Ed. 598..... 2
Reitz v. Mealey, 313 U. S. 597, 85 L. Ed. 1550..... 2
Rice v. Nash-Kelvinator Corp., 150 F (2d) 457, CCA-6 4
Schriber-Scroth Co. v. Cleveland Trust Co., 311 U. S. 211, 85 L. Ed. 132 ..... 2, 9
Selma Rome & Dalton R. R. Co. v. U. S., 122 U. S. 636, 30 L. Ed. 1249 2
Timken Detroit Axle Co. v. Cleveland Steel Products Corp., 148 F (2d) 267, CCA-6 6
Universal Oil Products Co. v. Globe Oil & Ref. Co., 322 U. S. 471, 88 L. Ed. 1399 7
U. S. v. One 1936 Ford Coach, 305 U. S. 666, 83 L. Ed. 432 2
U. S. v. Sischo, 262 U. S. 165, 67 L. Ed. 925..... 2

IN THE

Supreme Court of the United States

OCTOBER TERM, 1945.

No. 290.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation, *Petitioner*,

v.

CRANFORD P. WALKER AND CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER AND MILO C. KETCHUM, doing business as Depthograph Company, a copartnership, *Respondents*.

PETITION BY THE HALLIBURTON OIL WELL CEMENTING COMPANY FOR REHEARING OR OTHER RELIEF AND FOR STAY OF ISSUANCE OF MANDATE.

Comes now Halliburton Oil Well Cementing Company, Petitioner in the above cause, and respectfully prays for a rehearing or other relief and for a stay of issuance of the mandate of this Court.

The judgment of the Ninth Circuit Court of Appeals (146 F. (2d) 817 and 149 F. (2d) 896, R. 1594, 1614) holding patent 2,156,519 valid and infringed was affirmed by this Court on January 28, 1946, by an order *per curiam*, this Court being equally divided.

Petitioner prays for an order vacating the order of January 28, 1946 and for a rehearing on the two questions of law involved in this cause, or, in the alternative, for an order vacating the order of January 28, 1946, and remanding the cause to the Ninth Circuit Court of Appeals for a ruling by that Court on what effect the decision of this Court in *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, has upon the facts of this case.

An equal division of the Justices of this Court on questions of public importance only protracts their final adjudication and is recognized as a tragedy. Because of this, cases involving important Federal questions upon which majorities of the Court do not concur are sometimes restored to the docket for reargument before a full bench, this practice being initiated in *Mayor of New York* v. *Miln*, 8 Peters 120, 33 U. S. 120, 8 L. Ed. 888.

In the following cases, petitions for rehearing were granted under such conditions. *Home Insurance Company* v. *New York*, 134 U. S. 594, 33 L. Ed. 1025 (see 119 U. S. 129, 30 L. Ed. 350, for affirmance by a divided Court); The *Selma Rome & Dalton R. R. Co.* v. *U. S.*, 122 U. S. 636, 30 L. Ed. 1249; *U. S.* v. *Sischo*, 262 U. S. 165, 67 L. Ed. 925 (see 260 U. S. 697, 67 L. Ed. 469, for affirmance by a divided Court); *Bernards* v. *Johnson*, 313 U. S. 597, 85 L. Ed. 1550 (see 313 U. S. 537, 85 L. Ed. 1507 for affirmance by a divided Court); *Gray* v. *Powell*, 313 U. S. 596, 85 L. Ed. 1550 (see 312 U. S. 666, 85 L. Ed. 1111 for affirmance by a divided Court); *U. S.* v. *One 1936 Ford Coach*, 305 U. S. 666, 83 L. Ed. 432 (see 305 U. S. 564, 83 L. Ed. 355 for affirmance by a divided Court); *Railroad Commission of California* v. *Pacific Gas & Electric Co.*, 302 U. S. 771, 82 L. Ed. 598 (see 301 U. S. 669, 81 L. Ed. 1333 for affirmance by a divided Court); *Lesenba* v. *State of California*, 313 U. S. 597, 85 L. Ed. 1550, (see 313 U. S. 537, 85 L. Ed. 1507 for affirmance by a divided Court); *Reitz* v. *Mealey*, 313 U. S. 597, 85 L. Ed. 1550 (see 313 U. S. 542, 85 L. Ed. 1510 for affirmance by a divided Court); *Baltimore and Ohio R. R.* v. *Kepner*,

313 U. S. 597, 85 L. Ed. 1550 (see 313 U. S. 542, 85 L. Ed. 1510 for affirmance by a divided Court).

Especially is a rehearing desirable in the present case, since, at the time of the hearing, three of the Justices were absent from the bench due to illness or because of duties elsewhere. Unlike a situation where a Justice is disqualified for some reason, on rehearing there is "the expectation that a larger number of the Judges may then be present." *Mayor of New York* v. *Miln, supra.*

THE CASE OF GENERAL ELECTRIC CO. v. WABASH APPLIANCE CORP., 304 U. S. 364, SHOULD BE INTERPRETED.

The first question raised by the case at bar is concerned with the application of the doctrine of *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, 82 L. Ed. 1402 to a claim of a patent on a combination of elements.

This is a question of great public importance. In the few years since the opinion in the *General Electric Co.* v. *Wabash* case was delivered, it has been cited and relied on by the lower courts in many cases. Perhaps no opinion of this Court has more clearly set forth the law on the use of functional language in the claims of a patent.

Judge Denman has stated (149 F (2d) 896, R. 1615) that the case at bar is one of "novel import" in its application of the doctrine of the *General Electric* v. *Wabash* case to claims on a *combination* of elements.

But several Circuit Courts of Appeals and the Court of Customs and Patent Appeals have cited the *General Electric* v. *Wabash* case in support of rulings that *structural* rather than *functional* limitations must be employed in claims on *combinations* to define the novelty of the invention. These cases are in direct conflict with the rulings of the Ninth Circuit Court of Appeals in the present case that the doctrine of the *General Electric* v. *Wabash* case applies only to claims to a "single element" (149 F (2d) 896, R. 1614) or "specific product" (149 F (2d) 896, R. 1616).

These conflicting cases are reviewed briefly here.

In *Rice* v. *Nash-Kelvinator Corp.*, 150 F. (2d) 457, (CCA-6), decided since the Ninth Circuit Court of Appeals rendered its decision in the case at bar, a patent on a refrigeration machine was involved. Claim 3 called for a *combination* of old elements, a compressor, a condenser, an evaporator and pipe connections, with a new element, a *capillary tube*. The claim was thus identical in form with that of the claims in the case at bar. The Sixth Circuit Court of Appeals stated:

> "Claim 3 requires a capillary tube such as will maintain the predetermined ratio described above 'and minimize any tendency of the tube to clog, the said parts of the refrigerating machine and the refrigerant charge being so co-ordinated that the single capillary tube is adapted to function as the regulating device of the flow between the condenser and the evaporator and by reason of the said co-ordination the liquid level in the evaporator is maintained between narrow limits.'
>
> "These portions of the claims describe not the structure, but the function or purpose to be achieved by the tube. This practice has recently been condemned. General Electric Co. v. Wabash Appliance Corporation, 304 U. S. 364, 371, 58 S. Ct. 899, 82 L. Ed. 1402; United Carbon Co. v. Binney & Smith Co., 317 U. S. 228, 234, 63 S. Ct. 165, 87 L. Ed. 232."
>
> —150 F (2d) 460.

In another recent case, *Application of Horton et al*, 151 F (2d) 210, the Court of Customs and Patent Appeals had before it a number of claims on combinations of elements. These had been rejected by the Examiner and the Board of Appeals in the Patent Office because "their broad and indefinite language fails to make a clear distinction" over the prior art. The Court of Customs and Patent Appeals reversed the Patent Office tribunals as to some of the claims because they contained structural limitations, but it affirmed the Patent Office tribunals as to those claims which attempted to distinguish from the prior art only by functional limitations, the Court stating:

"The board was further of opinion, as stated in its decisions, that the claims here on appeal do not define the 'generic novelty' of appellants' device in terms of structure, but rather in terms of function.

"If the latter holding of the board is correct, the rejection should be sustained, since claims drawn to apparatus cannot be allowed unless they distinguish from the prior art in terms of structure. In re Skaupy, 67 F. 2d 492, 21 C.C.P.A., Patents, 712; In re Carr, 120 F. 2d 386, 28 C.C.P.A., Patents, 1240; General Electric Co. v. Wabash Appliance Corp, et al., 304 U. S. 364, 370, 371, 58 S. Ct. 899, 82 L. Ed. 1402."

—151 F (2d) 213.

In *Kool Kooshion Mfg. Co.* v. *Mitchell Mfg. Co.*, 102 F (2d) 37, (CCA-8), a patent on a combination of several elements was involved. The Court stated:

"Appellee urges that claim 3 is invalid as being indefinite in that it specifies no definite fabric enclosure nor any definite means of extending and holding extended the cushion. There is serious question whether this criticism is not well founded under the doctrine of General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, 370-375, 58 S. Ct. 899, 82 L. Ed. 1402."

—102 F (2d) 38.

In *Allen-Bradley Co.* v. *Erie Resistor Corp.*, 104 F (2d) 150 (CCA-3), the following claim was involved:

"7. As an article of manufacture, an electrical resistor unit having as ingredients thereof, a non-conducting material serving as a filler, a suitable material affording a binder, and carbon black calcined to substantially graphitizing temperature."

—104 F (2d) 151.

The Court stated:

"The appellant therefore is caught between the horns of a dilemma. If the phrase 'to substantially graphitizing temperatures' as used in the claims be construed to mean what we think Power and Bradley must have intended it to mean, viz., calcining temper-

atures of not less than 1927° centigrade, we must also hold that the appellee's processes do not infringe the three claims now under discussion. If, upon the other hand, we do not so interpret the phrase referred to in the claims in question, there is no doubt that the claims are invalid for want of definiteness. General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, 371, 58 S. Ct. 899, 82 L. Ed. 1402, 1407. (Other cases cited). So regarding, and without passing upon the validity of the disclosures of the patent over the prior art, we concur in the ruling of the District Judge that claims 4, 7, and 8 of the patent are not infringed by the appellee's processes."

—104 F (2d) 152.

In *Hazeltine Corporation* v. *Emerson Television-Radio, Inc.*, 129 F (2d) 580, (CCA-2) the following claim to a combination was involved:

"5. The combination of a large conical diaphragm, with a casing open at opposite ends disposed about the edge of said diaphragm and providing an open sound chamber at the rear of said diaphragm serving to enhance the operation thereof throughout its frequency range."

—129 F (2d) 581.

The Court stated:

"The term 'large diaphragm' had an accepted meaning in the art. Otherwise claims 1, 3 and 5, which call for a 'large' diaphragm, might well be thought so vague as to be invalid. Cf. B. B. Chemical Co. v. Cataract Chemical Co., 2 Cir., 122 F. 2d 526, 530; General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, 58 S. Ct. 899, 82 L. Ed. 1402."

—129 F (2d) 581

See also *In Re Cohen*, 133 F (2d) 924, 928, 929, (C.C. P.A.); *Timken Detroit Axle Co.* v. *Cleveland Steel Products Corp.*, 148 F (2d) 267, 269, (CCA-6).

Except for the ruling of the Ninth Circuit Court of Appeals in the case at bar, we have found no case holding

that the doctrine of *General Electric* v. *Wabash Appliance Corp.*, 304 U. S. 364, should be limited, in its application, to claims on a *single element*. It has universally been held that the case sets forth the doctrine "that functional statements cannot be availed of to define over the prior art." *Mead Johnson & Co.* v. *Hillman's Inc.*, 135 F (2d) 955, 958, (CCA-7). As stated by the Court of Appeals for the District of Columbia in *Minnesota Mining & Mfg. Co.* v. *Coe*, 113 F. (2d) 512, 513, in an opinion by Associate Justice Rutledge,

> "It has been held that a description by function does not comply with the statutory requirement that the inventor 'shall particularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery.' Rev. Stat. Sec. 4888, 35 U.S.C. (1934) Sec. 33, 35 U.S.C.A. Sec. 33; General Electric Co. v. Wabash Co., 1938, 304 U. S. 364, 58 S. Ct. 899, 82 L. Ed. 1402; Koebel v. Coe, 1939, 70 App. D.C. 261, 105 F. 2d 784."

This Court has not heretofore limited the doctrine to the "single element" class of invention involved in the *General Electric v. Wabash* case. In *Universal Oil Products Co.* v. *Globe Oil & Ref. Co.*, 322 U. S. 471, 484, 88 L. Ed. 1399, 1407, the case is cited and the doctrine applied to process claims.

The Ninth Circuit Court of Appeals itself seems to be in doubt as to the application of the doctrine of the *General Electric* v. *Wabash* case to claims on a combination of elements. In *John Bean Mfg. Co.* v. *Creagmile*, 123 F (2d) 182, claims to a combination were involved. In the opinion written by Judge Denman, there is an analysis of the claims there involved similar to Judge Denman's analysis (149 F. (2) 896, R. 1615) of one of the claims in the case at bar, and the opinion then states:

> "We believe there is grave doubt as to whether or not these claims are valid on their face on the ground of their failure to make disclosure sufficiently definite to satisfy the requirements of R. S. 4888, 35 U.S.C.A. Sec. 33. Cf. General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, 368-370, 58 S. Ct. 899, 82 L.

Ed. 1402. However, we have resolved our doubt in favor of examining into the question of novelty and anticipation."

—123 F (2d) 184.

See also *Farmers Cooperative Exchange* v. *Turnbow*, 111 F (2d) 738 (CCA-9), where claims to a combination were held invalid because they used "conveniently functional language at the exact point of novelty."

Respondents rely upon *Continental Paper Bag Co.* v. *Eastern Paper Bag Co.*, 210 U. S. 405, in support of their contention that it is proper to use only functional limitations to define the novel element in a claim to a combination. The *Paper Bag Case* is analyzed in *Davis Sewing Machine Co.* v. *New Departure Mfg. Co.*, 217 F. 775, 783, (CCA-6), and for the reasons there given, we believe that no such construction is warranted. As shown by the above cited cases, the construction of the *Paper Bag Case* sought by Respondents is entirely contrary to the generally accepted interpretation of the *General Electric* v. *Wabash* case.

The Ninth Circuit Court of Appeals has ruled that the *General Electric* v. *Wabash* case is distinguishable from the facts in the case at bar because the patent involved there was for a specific product instead of for a combination (149 F (2d) 896, R. 1616). Affirmance of the decision of the Ninth Circuit Court of Appeals by an equally divided Court can create nothing but confusion. We urge that this case be restored to the docket for reargument before a full bench so that the correct interpretation of the *Paper Bag Case* and the *General Electric* v. *Wabash* case may be settled.

THE CASE OF SCHRIBER-SCHROTH v. CLEVELAND TRUST CO., 311 U. S. 211, SHOULD BE CONSIDERED IN CONNECTION WITH THE FACTS IN THIS CASE.

Affirmance by an equally divided Court of the decision of the Ninth Circuit Court of Appeals on the second question involved in this cause presents an anomalous situation, for the Court of Appeals has not ruled on this question. Petitioner pleaded "file wrapper estoppel" (R. 17) and assigned as error (R. 40) the failure of the District Court to find that the proceedings in the Patent Office estopped Respondents from asserting equivalency between an electrical filter and an acoustical tuned resonator. The Circuit Court of Appeals ignored the proceedings in the Patent Office and rendered no decision as to the effect of those proceedings. This Court granted certiorari, Petitioner relying upon, as one of three reasons for the allowance of the writ:

> "2. That the Circuit Court of Appeals for the Ninth Circuit, by ignoring the rejection, cancellation and abandonment of a claim in a copending application for patent, has so construed the claims in suit as to cause them to cover subject matter refused Respondents by the Patent Office and has imposed undue restrictions on the rules governing the construction of claims set forth in Schriber-Schroth Co. v. Cleveland Trust Co., 311 U. S. 211, 220, 221, 85 L. Ed. 132, 137, 138."

The affirmance by an equally divided Court leaves this question undecided. It is not even mentioned in any decision. Surely, Petitioner is entitled to a ruling by some Court as to the merits of this defense. If a rehearing by this Court before a full bench is not feasible, it is urged that this Court vacate the order of January 28, 1946, and remand the case to the Ninth Circuit Court of Appeals for

action on this question, following the procedure outlined in *Cole* v. *Ralph*, 252 U. S. 286, 290, 64 L. Ed. 567, 574.

Respectfully submitted,

EARL BABCOCK,
HARRY C. ROBB,
Attorneys for Petitioner.

I, Harry C. Robb, attorney for the above named Petitioner, do hereby certify that the foregoing petition for rehearing or other relief and for stay of issuance of mandate is presented in good faith and not for delay.

HARRY C. ROBB.

February 15, 1946.

p. 1

SUPREME COURT OF THE UNITED STATES

No. 24—October Term, 1946.

Halliburton Oil Well Cementing Company, Petitioner, v. Cranford P. Walker, et al., doing business as Depthograph Company, a Corporation.	On Writ of Certiorari to the United States Circuit Court of Appeals for The Ninth Circuit.

[November 18, 1946.]

Mr. Justice Black delivered the opinion of the Court.

Cranford P. Walker, owner of Patent No. 2,156,519, and the other respondents, licensees under the patent, brought this suit in a federal district court alleging that petitioner, Halliburton Oil Well Cementing Company, had infringed certain of the claims of the Walker patent. The district court held the claims in issue valid and infringed by Halliburton. The circuit court of appeals affirmed, 146 F. 2d 817, and denied Halliburton's petition for rehearing. 149 F. 2d 896. Petitioner's application to this Court for certiorari urged, among other grounds, that the claims held valid failed to make the "full, clear, concise, and exact" description of the alleged invention required by Rev. Stat. 4888, 35 U. S. C. § 33,[1] as that statute was interpreted by us in *General Electric Co.* v. *Wabash Elec-*

[1] "33. Application for Patent; Description; Specification and Claim.—Before any inventor or discoverer shall receive a patent for his invention or discovery he shall make application therefor, in writing, to the Commissioner of Patents, and shall file in the Patent Office a written description of the same, and of the manner and process of making, constructing, compounding, and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct, compound, and use

tric Co., 304 U. S. 364.[2] This statutory requirement of distinctness and certainty in claims is important in patent law. We granted certiorari to consider whether it was correctly applied in this case. 326 U. S. 705.[3]

The patent in suit was sustained as embodying an improvement over a past patent of Lehr and Wyatt (No. 2,047,974) upon an apparatus designed to facilitate the pumping of oil out of wells which do not have sufficient natural pressures to force the oil to gush. An outline of the background and setting of these patents is helpful to an understanding of the problem presented.

In order to operate a pump in an oil well most efficiently, cheaply, and with the least waste, the pump must be placed in an appropriate relationship to the fluid surface of the oil. Properly to place the pump in this relationship requires knowledge of the distance from the well top to the fluid surface. At least by the latter 1920's problems of waste and expense in connection with non-gusher oil wells pressed upon the industry. See *Railroad Comm'n. of Texas* v. *Rowan and Nichols Oil Co.*, 310 U. S. 573; *Burford* v. *Sun Oil Co.*, 319 U. S. 315. It became apparent that inefficient pumping, one cause of waste, was in some measure attributable to lack of accurate knowledge of distance from well top to fluid surface. Ability to measure this distance in each separate non-gusher oil well became an

---

the same; and in case of a machine, he shall explain the principle thereof, and the best mode in which he has contemplated applying that principle, so as to distinguish it from other inventions; and he shall particularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery . . ."

[2] Other alleged errors were urged in the application for certiorari and have been argued here, but since we find the question of definiteness of the claim decisive of the controversy, we shall not further advert to the other contentions.

[3] This case was previously affirmed by a divided court, 326 U. S. 696, and upon petition for rehearing was restored to the docket for reargument. — U. S. —.

obvious next step in the solution of this minor aspect of the problem of waste.

The surface and internal machinery and the corkscrew conformation of some oil wells make it impractical to measure depth by the familiar method of lowering a rope or cable. In casting about for an alternative method it was quite natural to hit upon the possibility of utilizing a sound-echo-time method. Unknown distances had frequently been ascertained by this method. Given the time elapsing between the injection of a sound into an oil well and the return of its echo from the fluid surface, and assuming the velocity of the sound to be about 1100 feet per second, as it is in the open air, it would be easy to find the distance. Not only had this sound-echo-time method been long known and generally used to find unknown distances, but in 1898 Batcheller, in Patent No. 602,422, had described an apparatus to find a distance in a tubular space. Obviously an oil well is such a space. He described a device whereby the noise from a gun might be injected into a tube; the returning echoes from obstructions agitated a diaphragm, which in turn moved a stylus. The stylus recorded on a piece of paper a graph or diagram showing the variant movements of the diaphragm caused by its response to all the different echo waves.

In the late 1920's the oil industry began to experiment in the use of this same sound-echo-time method for measuring the distance to the fluid surface in deep oil wells. A product of this experimentation was the Lehr and Wyatt patent, upon which the present patent claims to be an improvement. It proposed to measure the distance by measuring the time of travel of the echo of "an impulse wave" generated by a "sudden change in pressure." The apparatus described included a gas cylinder with a quick operating valve by means of which a short blast of gas could be injected into a well. It was stated in the patent that the time elapsing between the release of the gas and the return of the echo of the waves produced by it could be

observed in any desired manner. But the patentee's application and drawings noted that the wave impulses could be recorded by use of a microphone which might include an amplifier and an appropriate device to record a picture of the wave impulses.

This Lehr and Wyatt patent, it is therefore apparent, simply provided an apparatus composed of old and well-known devices to measure the time required for pressure waves to move to and back from the fluid surface of an oil well. But the assumption that sound and pressure waves would travel in oil wells at open-air velocity of 1100 feet per second proved to be erroneous. For this reason the time-velocity computation of Lehr and Wyatt for measuring the distance to the fluid surface produced inaccurate results.

After conferences with Lehr, Walker undertook to search for a method which would more accurately indicate the sound and pressure wave velocity in each well. Walker was familiar with the structure of oil wells. The oil flow pipe in a well, known as a tubing string, is jointed and where these joints occur there are collars or shoulders. There are also one or more relatively prominent projections on the oil flow pipe known as tubing catchers. In wells where the distance to the tubing catcher is known, Walker observed that the distance to the fluid surface could be measured by a simple time-distance proportion formula.[4] For those wells in which the distance to the

[4] The known distance from well top to the tubing catcher is to the unknown distance from well top to the fluid surface as the time an echo requires to travel from the tubing catcher is to the time required for an echo to travel from the fluid surface.

Walker's patent emphasizes that his invention solves the velocity of sound waves in wells of various pressures in which sound did not travel at open-air or a uniform speed. Mathematically, of course, his determination of the distance by proportions determines the distance to the fluid surface directly without necessarily considering velocity in feet per second as a factor.

tubing catcher was unknown, Walker also suggested another idea. The sections of tubing pipe used in a given oil well are generally of equal length. Therefore the shoulders in a given well ordinarily are at equal intervals from each other. But the section length and therefore the interval may vary from well to well. Walker concluded that he could measure the unknown distance to the tubing catcher if he could observe and record the shoulder echo waves. Thus multiplication of the number of shoulders observed by the known length of a pipe section would produce the distance to the tubing catcher. With this distance, he could solve the distance to the fluid surface by the same proportion formula used when the distance to the tubing catcher was a matter of record. The Lehr and Wyatt instrument could record all these echo waves. But the potential usefulness of the echoes from the shoulders and the tubing catcher which their machine recorded had not occurred to Lehr and Wyatt and consequently they had made no effort better to observe and record them. Walker's contribution which he claims to be invention was in effect to add to Lehr and Wyatt's apparatus a well-known device which would make the regularly appearing shoulder echo waves more prominent on the graph and easier to count.

The device added was a mechanical acoustical resonator. This was a short pipe which would receive wave impulses at the mouth of the well. Walker's testimony was, and his specifications state, that by making the length of this tubal resonator one-third the length of the tubing joints, the resonator would serve as a tuner, adjusted to the frequency of the shoulder echo waves. It would simultaneously amplify these echo waves and eliminate unwanted echoes from other obstructions thus producing a clearer picture of the shoulder echo waves. His specifications show, attached to the tubal resonator, a coupler, the manipulation of which would adjust the length of the tube

to one-third of the interval between shoulders in a particular well. His specifications and drawings also show the physical structure of a complete apparatus, designed to inject pressure impulses into a well, and to receive, note, record and time the impulse waves.

The district court held the claims here in suit valid upon its finding that Walker's "apparatus differs from and is an improvement over the prior art in the incorporation in such apparatus of a tuned acoustical means which performs the functions of a sound filter . . . ." The circuit court of appeals affirmed this holding, stating that the trial court had found "that the only part of this patent constituting invention over the prior art is the 'tuned acoustical means which performs the functions of a sound filter.'"

For our purpose in passing upon the sufficiency of the claims against prohibited indefiniteness we can accept without ratifying the findings of the lower court that the addition of "a tuned acoustical means" performing the "functions of a sound filter" brought about a new patentable combination, even though it advanced only a narrow step beyond Lehr and Wyatt's old combination.[5] We must, however, determine whether, as petitioner charges, the claims here held valid run afoul of Rev. Stat. 4888 because they do not describe the invention but use "conveniently functional language at the exact point of novelty." *General Electric Co.* v. *Wabash Electric Co.*, *supra*, at 371.

Walker, in some of his claims, *e. g.*, claims 2 and 3, does describe the tuned acoustical pipe as an integral part of his invention, showing its structure, its working arrangement in the alleged new combination, and the manner of

---

[5] See *Hailes* v. *Van Wormer*, 20 Wall. 353; *Knapp* v. *Morss*, 150 U. S. 221, 227–28; *Textile Machine Works* v. *Louis Hirsch Textile Machines, Inc.*, 302 U. S. 490; *Lincoln Engineering Co.* v. *Stewart Warner Corp.*, 303 U. S. 545, 549–50.

its connection with the other parts. But no one of the claims on which this judgment rests has even suggested the physical structure of the acoustical resonator.[6] No one of these claims describes the physical relation of the Walker addition to the old Lehr and Wyatt machine. No one of these claims describes the manner in which the Walker addition will operate together with the old Lehr and Wyatt machine so as to make the "new" unitary apparatus perform its designed function. Thus the claims failed adequately to depict the structure, mode, and operation of the parts in combination.

A claim typical of all of those held valid only describes the resonator and its relation with the rest of the apparatus as "means associated with said pressure responsive device for tuning said receiving means to the frequency of echoes from the tubing collars of said tubing section to clearly distinguish the echoes of said couplings from each other."[7] The langauge of the claim thus describes this

---

[6] Halliburton does not challenge the adequacy of the description of any other features of the "new combination." The elements of Walker's apparatus other than the filter are so nearly identical to what Lehr and Wyatt patented that we can speak of these other elements as the "Lehr and Wyatt machine."

[7] Both parties have used Claim 1 as a typical example for purposes of argument throughout the litigation. Other claims need not be set out. Claim 1 is as follows:

"In an apparatus for determining the location of an obstruction in a well having therein a string of assembled tubing sections interconnected with each other by coupling collars, means communicating with said well for creating a pressure impulse in said well, echo receiving means including a pressure responsive device exposed to said well for receiving pressure impulses from the well and for measuring the lapse of time between the creation of the impulse and the arrival at said receiving means of the echo from said obstruction, and means associated with said pressure responsive device for tuning said receiving means to the frequency of echoes from the tubing collars of said tubing sections to clearly distinguish the echoes from said couplings from each other."

most crucial element in the "new" combination in terms of what it will do rather than in terms of its own physical characteristics or its arrangement in the new combination apparatus. We have held that a claim with such a description of a product is invalid as a violation of Rev. Stat. 4888. *Holland Furniture Co.* v. *Perkins Glue Co.*, 277 U. S. 245, 256–57; *General Electric Co.* v. *Wabash Electric Co.*, *supra*. We understand that the circuit court of appeals held that the same rigid standards of description required for product claims is not required for a combination patent embodying old elements only. We have a different view.

Rev. Stat. 4888 pointedly provides that "in the case of a machine, he [the patentee] shall explain the principle thereof, and the best mode in which he has contemplated applying the principle, so as to distinguish it from other inventions; and he shall particularly point out and distinctively claim the part, improvement, or combination which he claims as his invention or discovery." It has long been held that the word "machine" includes a combination. *Corning et al.* v. *Burden*, 15 How. 252, 267. We are not persuaded that the public and those affected by patents should lose the protection of this statute merely because the patented device is a combination of old elements.

Patents on machines which join old and well-known devices with the declared object of achieving new results, or patents which add an old element to improve a pre-existing combination, easily lend themselves to abuse. And to prevent extension of a patent's scope beyond what was actually invented, courts have viewed claims to combinations and improvements or additions to them with very close scrutiny. *Cf. Lincoln Engineering Co.* v. *Stewart Warner Corp.*, 303 U. S. 545, 549–51. For the same reason, courts have qualified the scope of what is meant by the equivalent of an ingredient of a combination of old elements. *Gill* v. *Wells*, 22 Wall. 1, 28, 29. *Fuller* v. *Yentz-*

ler, 94 U. S. 288, 297, 298. It is quite consistent with this strict interpretation of patents for machines which combine old elements to require clear description in combination claims. This view, clearly expressed in *Gill* v. *Wells*, *supra*, is that

> "Where the ingredients are all old the invention . . . consists entirely in the combination, and the requirement of the Patent Act that the invention shall be fully and exactly described applies with as much force to such an invention as to any other class, because if not fulfilled all three of the great ends intended to be accomplished by that requirement would be defeated. . . . (1.) That the Government may know what they have granted and what will become public property when the term of the monopoly expires. (2.) That licensed persons desiring to practice the invention may know, during the term, how to make, construct, and use the invention. (3.) That other inventors may know what part of the field of invention is unoccupied.
>
> "Purposes such as these are of great importance in every case, but the fulfillment of them is never more necessary than when such inquiries arise in respect to a patent for a machine which consists of a combination of old ingredients. Patents of that kind are much more numerous than any other, and consequently it is of the greatest importance that the description of the combination, which is the invention, should be full, clear, concise, and exact." *Gill* v. *Wells*, *supra*, at 25–26.

These principles were again emphasized in *Merrill* v. *Yeomans*, 94 U. S. 568, 570, where it was said that ". . . in cases where the invention is a new combination of old devices, he [the patentee] is bound to describe with particularity all these old devices, and then the new mode of combining them, for which he desires a patent." This view has most recently been reiterated in *General Electric Co.* v. *Wabash Electric Co.*, *supra* at 368, 369. Cogent reasons would have to be presented to persuade us to

depart from this established doctrine. The facts of the case before us, far from undermining our confidence in these earlier pronouncements, reinforce the conclusion that the statutory requirement for a clear description of claims applies to a combination of old devices.

This patent and the infringement proceedings brought under it illustrate the hazards of carving out an exception to the sweeping demand Congress made in Rev. Stat. 4888. Neither in the specification, the drawing, nor in the claims here under consideration, was there any indication that the patentee contemplated any specific structural alternative for the acoustical resonator or for the resonator's relationship to the other parts of the machine. Petitioner was working in a field crowded almost, if not completely, to the point of exhaustion. In 1920, Tucker, in Patent No. 1,451,356, had shown a tuned acoustical resonator in a sound detecting device which measured distances. Lehr and Wyatt had provided for amplification of their waves. Sufficient amplification and exaggeration of *all* the different waves which Lehr and Wyatt recorded on their machine would have made it easy to distinguish the tubing catcher and regular shoulder waves from all others. For, even without this amplification, the echo waves from tubing collars could by proper magnification have been recorded and accurately counted, had Lehr and Wyatt recognized their importance in computing the velocity. *Cf. General Electric Co.* v. *Jewel Incandescent Lamp Co.*, 326 U. S. 242.

Under these circumstances the broadness, ambiguity, and verhanging threat of the functional claim of Walker become apparent. What he claimed in the court below and what he claims here is that his patent bars anyone from using in an oil well any device heretofore or hereafter invented which combined with the Lehr and Wyatt machine performs the function of clearly and distinctly catching and recording echoes from tubing joints with

regularity. Just how many different devices there are of various kinds and characters which would serve to emphasize these echoes, we do not know. The Halliburton device, alleged to infringe, employs an electric filter for this purpose. In this age of technological development there may be many other devices beyond our present information or indeed our imagination which will perform that function and yet fit these claims. And unless frightened from the course of experimentation by broad functional claims like these, inventive genius may evolve many more devices to accomplish the same purpose. See *United Carbon Co. et al.* v. *Binney & Smith Co.*, 317 U. S. 228, 236; *Burr* v. *Duryee*, 1 Wall. 531, 568; *O'Reilly, et al.* v. *Morse, et al.*, 15 How. 62, 112–13. Yet if Walker's blanket claims be valid, no device to clarify echo waves, now known or hereafter invented, whether the device be an actual equivalent of Walker's ingredient or not, could be used in a combination such as this, during the life of Walker's patent.

Had Walker accurately described the machine he claims to have invented, he would have had no such broad rights to bar the use of all devices now or hereafter known which could accent waves. For had he accurately described the resonator together with the Lehr and Wyatt apparatus, and sued for infringement, charging the use of something else used in combination to accent the waves, the alleged infringer could have prevailed if the substituted device (1) performed a substantially different function; (2) was not known at the date of Walker's patent as a proper substitute for the resonator; or (3) had been actually invented after the date of the patent. *Fuller* v. *Yentzler, supra*, at 296–97; *Gill* v. *Wells, supra*, at 29. Certainly, if we are to be consistent with Rev. Stat. 4888, a patentee cannot obtain greater coverage by failing to describe his invention than by describing it as the statute commands.

It is urged that our conclusion is in conflict with the decision of *Continental Paper Bag Co.* v. *Eastern Paper Bag Co.*, 210 U. S. 405. In that case, however, the claims structurally described the physical and operating relationship of all the crucial parts of the novel combination.[8] The court there decided only that there had been an infringement of this adequately described invention. That case is not authority for sustaining the claims before us which fail adequately to describe the alleged invention.

Reversed.

MR. JUSTICE FRANFURTER concurs with the Court's opinion in so far as it finds this claim lacking in the definiteness required by Rev. Stat. 4888, 35 U. S. C. § 33, but reserves judgment as to considerations that may be peculiar to combination patents in satisfying that requirement.

MR. JUSTICE BURTON dissents.

---

[8] The typical claim there in suit was as follows:

"2. In a paper bag machine, the combination of the rotating cylinder provided with one or more pairs of side folding fingers adapted to be moved toward or from each other, a forming plate also provided with side forming fingers adapted to be moved toward or from each other, means for operating said fingers at definite times during the formative action upon the bag tube, operating means for the forming plate adapted to cause the said plate to oscillate about its rear edge upon the surface of the cylinder during the rotary movement of said cylinder for the purpose of opening and forming the bottom of the bag tube, a finger moving with the forming plate for receiving the upper sheet of the tube and lifting it during the formative action, power devices for returning the forming plate to its original position to receive a new bag tube, and means to move the bag tube with the cylinder." *Continental Paper Bag Co.* v. *Eastern Paper Bag Co.*, 210 U. S. 405, 417, n. 1.